PROCEDURES
FOR THE ASSESSMENT OF
SOLID WASTE
RESIDENTIAL AND COMMERCIAL

VOLUME III
OF THE
ONTARIO WASTE COMPOSITION STUDY

JULY 1991

Ontario

Environment
Environnement

ISBN 0-7729-9131-6

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RESIDENTIAL AND COMMERCIAL

VOLUME III
OF THE ONTARIO WASTE COMPOSITION STUDY

Report prepared for:

Waste Reduction Office
Ministry of the Environment

Report prepared by:

Gore & Storrie Limited

July 1991
Revised December 1991

PRINTED ON
RECYCLED PAPER
IMPRIMÉ SUR
DU PAPIER RECYCLÉ

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PIBS 1609

92-03197/

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INFORMATION FOR THE READER

The results of the Ontario Waste Composition Study appear in three volumes.

Volume I contains the results of the residential portion of the Ontario Waste Composition Study. The emphasis in Volume I is on the development and testing of a method that municipalities can use to estimate per capita generation rates of residential refuse. The field work for Volume I took place in East York, Fergus, and North Bay, Ontario.

Volume II contains the results of the commercial portion of the Ontario Waste Composition Study. Waste generation data for two light industrial businesses are also provided in Volume II. The emphasis in Volume II is on the development and testing of a method that municipalities can use to estimate per employee waste generation rates and, further, to estimate the quantity of waste generated from all commercial sources. The commercial component of the study took place in the Regional Municipality of Waterloo.

Volume III is a "user friendly" manual that outlines the procedures for conducting residential and commercial waste composition studies in municipalities of Ontario. While every effort has been made to present as complete a description of the method as possible there will be instances where the persons conducting a waste study will find it necessary to make adjustments to this method to suit particular circumstances.

Volume III is divided in two parts. Part A provides a description of the methodology used to conduct the Residential Waste Composition Study. Part B describes the methodology used to conduct the Commercial Waste Composition Study.

PART A

RESIDENTIAL WASTE COMPOSITION STUDY METHODS

TABLE OF CONTENTS-- PART A

Page No.

DISCLAIMER (i)

INFORMATION FOR THE READER (ii)

TABLE OF CONTENTS (iv)

LIST OF TABLES (v)

LIST OF FIGURES (vi)

EXECUTIVE SUMMARY (vii)

1.0 WHY CONDUCT A WASTE GENERATION AND COMPOSITION STUDY 1-1
- 1.1 Waste Management Planning 1-2
  - 1.1.1 Estimation of Total Waste Tonnage 1-2
  - 1.1.2 Estimation of Tonnage of Recyclable and Recoverable Material 1-3
  - 1.1.3 Estimation of Tonnage of Hazardous Materials 1-3

2.0 WASTE STUDY PARAMETERS AND CONSIDERATIONS 2-1
- 2.1 Required Waste Generation Rate and Waste Composition Data 2-1
  - 2.1.1 Waste Generation Rate 2-1
  - 2.1.2 Waste Composition 2-1
- 2.2 Income and Housing Basis for Defining Residential Waste Generation 2-2
  - 2.2.1 Knowing Your Community - Census Canada Information 2-3
  - 2.2.2 Knowing Your Community - Current Waste Management Practices 2-5
  - 2.2.3 Effect of Seasonality On Waste Generation 2-5
  - 2.2.4 Bulk Item and Special Collection Days 2-6
- 2.3 Sampling of Residential Waste 2-6
  - 2.3.1 Number of Samples Required in Each Enumeration Area 2-6
  - 2.3.2 Size of Samples Required 2-7

3.0 MANPOWER, EQUIPMENT AND COST 3-1
- 3.1 Field Crew Size Requirements 3-1
- 3.2 Equipment Requirements 3-2
  - 3.2.1 Waste Sample Collection Equipment 3-2
  - 3.2.2 Waste Sample Sorting and Measurement Equipment 3-4
  - 3.2.3 Personal Safety Equipment 3-4

Table of Contents cont'd...

3.2.4 Seasonal Effects on Equipment Requirements - Shelter and Clothing 3-4
3.3 Cost of Conducting a Typical Waste Study 3-5
3.3.1 Personnel Time Requirements and Costs 3-6

4.0 STAGE 1 - DEFINING THE INCOME/HOUSING MATRIX 4-1
4.1 Obtaining Statistics Canada Data 4-1
4.2 Municipal Income Stratification 4-1
4.2.1 Anytown: Stratifying Income level 4-2
4.3 Municipal Housing Type Characteristics 4-3
4.3.1 Anytown: Classifying Housing Type 4-3
4.4 Allocating Individual EAs to the Matrix Cells 4-4
4.4.1 Anytown: Allocating Individual EAs to Matrix Cells 4-4
4.5 Selecting the Study EAs 4-4
4.5.1 Anytown: Selecting the Study EAs 4-4

5.0 STAGE 2 - SELECTING SAMPLE POINTS WITHIN AN EA 5-1
5.1 Street Face Numbering 5-1
5.2 Random Selection of Starting Points 5-2

6.0 STAGE 3 - COLLECTION OF WASTE SAMPLE 6-1
6.1 Regular Curbside Waste 6-1
6.1.1 Waste Collection Process: Detached Dwellings General Procedures 6-1
6.1.2 Required Number of Samples 6-3
6.1.3 Required Weight of Each Sample 6-3
6.1.4 Collection Equipment Requirements 6-3
6.1.5 Twice Weekly Garbage Collection Sampling Protocol 6-4
6.1.6 Recording Number of Houses Passed and Weight of Sample 6-6
6.2 Blue Box Materials 6-6
6.3 Yard Waste and Seasonality 6-6
6.3.1 Collection and Analysis of Yard Waste 6-7
6.4 Large and Bulk Items 6-7
6.5 Apartment Buildings 6-8
6.5.1 Small Apartment Buildings 6-8
6.5.2 Highrise Apartment Buildings With Dumpsters and Compactors 6-9
6.6 Logistics of Sample Collection 6-10
6.6.1 Documents and Meetings 6-10

7.0 STAGE 4 - WASTE SORTING AND ANALYSIS 7-1
7.1 Sorting Location 7-1
7.2 Sorting Equipment and Set-up 7-2
7.3 Waste Component Categories 7-3

Table of Contents cont'd...

7.4 Weighing Sorted Waste - Use of Tared Buckets and Electronic Scales 7-5
7.5 Use of Standard Data Sheets - Recording Weights 7-6
7.6 Personnel Training - Safety 7-6
7.6.1 Waste Handling 7-6
7.6.2. Protective Clothing, Hygiene, and Immunization 7-6
7.7 Moisture Content Analysis - Optional 7-7
7.8 Other Optional Analyses - BTU, Leachable Metals 7-8
7.9 Yard Waste Data Collection 7-8

8.0 STAGE 5 - DATA ANALYSIS AND MANIPULATION 8-1
8.1 Using a Computerized Spreadsheet to Summarize Data 8-1
8.1.1 Percent Composition of Waste 8-2
8.2 Calculation of Per Capita Waste Generation Rate 8-2
8.2.1 Municipalities with Blue Box Recycling 8-3
8.2.2 Municipalities With No Blue Box Recycling 8-5
8.2.3 Estimation of a Weighted Generation Rate for the Municipality 8-5
8.3 Waste Component Generation Rate 8-6

9.0 ANALYSIS OF WASTE FROM SCHOOLS & OTHER INSTITUTIONS 9-1
9.1 Per Capita Waste Generation 9-1
9.2 Percent Waste Composition 9-1

10. RECOMMENDATIONS FOR FURTHER REFINEMENT 10-1

ACKNOWLEDGEMENTS

REFERENCES

GLOSSARY

LIST OF TABLES--PART A

		Following Page No.
TABLE 1	WASTE COMPOSITION CATEGORIES	2-2
TABLE 2	INCOME/HOUSING MATRIX USED FOR CLASSIFYING MUNICIPAL POPULATIONS	2-3
TABLE 3	ANYTOWN: CLASSIFYING ENUMERATION AREAS BY INCOME LEVEL	4-2
TABLE 4	ANYTOWN: CLASSIFYING ENUMERATION AREAS BY HOUSING TYPE	4-3
TABLE 5	ANYTOWN: ALLOCATING INDIVIDUAL ENUMERATION AREAS TO THE INCOME/HOUSING MATRIX CELLS	4-4
TABLE 6	ANYTOWN: RANDOMLY SELECTING ENUMERATION AREAS TO BE INCLUDED IN THE WASTE COMPOSITION STUDY	4-5
TABLE 7	WASTE COMPOSITION DATA COLLECTION SHEET	7-3
TABLE 8	SAMPLE CALCULATION OF THE PER CAPITA GENERATION RATE IN AN EA. DATA FROM THE FICTIONAL TOWN OF ANYTOWN, EA #107	8-2
TABLE 9	RESIDENTIAL WASTE GENERATION DATA INCORPORATED INTO THE INCOME/HOUSING MATRIX TO ESTIMATE THE WEIGHTED PER CAPITA GENERATION RATE (KG/CAPITA/DAY) FOR THE FICTIONAL TOWN OF ANYTOWN	8-6

LIST OF FIGURES--PART A

		Following Page No.
FIGURE 1	CATEGORIZING A MUNICIPAL POPULATION WITH RESPECT TO INCOME: THEORETICAL BASIS (2a) PRACTICAL APPLICATION (2b)	2-4
FIGURE 2	PHOTOGRAPH OF PICKUP TRUCK WITH COMPARTMENTS FOR BLUE BOX MATERIALS	3-3
FIGURE 3	PHOTOGRAPH OF CHICKEN WIRE CRIB MOUNTED ON THE PLATFORM SCALE (REAR VIEW OF CUBE VAN)	3-3
FIGURE 4	PHOTOGRAPH SHOWING THE POSITIONING OF THE STUDY TEAM AROUND THE TAILGATE SORTING TABLE	3-3
FIGURE 5	EXAMPLE OF ONE EA SHOWING NUMBERING OF BLOCK FACES AND SAMPLE COLLECTION "STARTING POINTS"	5-1

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Methodology

The two-fold purpose of the residential portion of the Ontario Waste Composition Study was to:

1. develop a simple, cost effective and statistically reliable method for determining the composition and per capita generation rate of waste from residential sources in Ontario municipalities; and

2. apply the method in several municipalities and obtain current information on the characteristics of residential waste streams.

The pre-study literature survey, summarized in Volume I - Residential Waste Composition Study, indicated that residential waste generation was a function of the socio-economic and demographic characteristics of a population. An assessment of the residential waste generation characteristics of a municipality should take population demographics into consideration.

The socio-economic and demographic parameters incorporated in the Residential Waste Composition Study are: income level and housing type. Statistics Canada provides census data with respect to these parameters for municipalities across the country and this kind of information was obtained for the three municipalities participating in the waste composition study in Ontario: the Town of Fergus (population: 6,757); the Borough of East York (population: 101,085); and the City of North Bay (population 51,313). The field studies were conducted in the three municipalities during the following periods: July 15 to August 31, 1989; October 24 to December 28, 1989; and February 21 to February 28, 1990 respectively.

Statistics Canada provides socio-economic and demographic information on small geographical sectors of municipalities called Enumeration Areas (EAs) that are made up of approximately 300 dwellings and typically have a residential population of 600-800 persons. Some highrise apartment buildings may have a large enough number of units that they are designated as EAs unto themselves.

In the work reported herein, the EA was the basic population unit whose waste composition and per capita generation rates were studied as representative segments of the entire municipal population. First, all of the EAs in the municipality were classified in a three-by-three, two dimensional matrix of:

Average annual income:	high, medium, and low; and
Housing type:	single detached dwellings, predominantly multiple dwellings (apts.), and predominantly mixed (detached/apts.).

This classification matrix resulted in nine possible combinations of income levels and housing types with each combination termed a "cell". One EA was randomly selected from each cell, unless the cell contained few or no EAs, which was often the case for the low income/single detached dwelling cell. The residential waste assessments in the Town of Fergus and the Borough of East York were based on data from EAs that were representative of the EA distribution in the income/housing matrix for the respective municipalities. Based on the results of these two municipalities, it was decided to conduct a reduced sampling program in the City of North Bay.

After the Study EAs in the municipality were randomly selected, a curbside refuse sampling plan was designed, based on a procedure that assigned random starting points for refuse collections at street intersections throughout the EA.

For each EA, both the number and weight of the refuse samples that had to be collected and sorted in order to obtain the statistical accuracy that was desired for the kitchen waste fraction (only) of residential waste was based on the pioneering work of Dr. A. Klee and co-workers. The sample number was a minimum of nine per EA; and the minimum sample weight was 100 kg. To achieve similar levels of statistical accuracy for waste components occurring at lower concentrations in the waste stream (for example, glass and ferrous metals), a greater number of samples, which may be economically impractical, would be required. To determine the number of samples required to accurately assess these waste components refer to Volume I, Section 1.2.

It took a crew of four, approximately 5.5 days to collect and sort the bagged refuse and Blue Box materials in a single EA. Records were kept of the number of dwellings from which bagged refuse and Blue Box materials were collected in order to compute estimates of total residential waste generation on a per capita basis, using Statistics Canada data on the average population per dwelling in the EA. Blue Box materials were sorted, weighed and recorded separately in order to estimate the capture rate of certain recyclable items from the residential waste stream.

Yard wastes were weighed and recorded whenever they were encountered, but this waste stream was not included in the computations of the residential waste composition and the weight was not included in the estimates of per capita generation rates either, for seasonal generation reasons discussed herein.

The moisture content of the combustible fractions of the waste stream was determined by drying. The BTU content of some mixed plastics (laminates), as well as disposable diapers, was determined by bomb calorimetry. Samples of vacuum cleaner bag dust were analyzed for heavy metals. The results of these analyses are presented in Volume I.

Special sampling procedures were devised for those apartment buildings where the waste was compacted in containers. Samples of the required weight were removed from the containers for the waste composition analysis. Then the residual contents were collected and weighed, courtesy of special arrangements made with a local waste hauler and transfer station scale house.
The weekly waste streams for seven schools in East York were also collected and the waste composition was determined. Per capita generation rates for the student body and total staff were computed.

A survey was also conducted to assess the yearly tonnages of white goods and other bulky items generated by residential areas in 10 municipalities in Ontario.

The methods developed and used in this study were found to be cost effective and capable of being used by municipal staff. Recommendations are presented in this volume and in Volume I to further refine and improve the methods used.

Ontario municipalities are encouraged to use the methods demonstrated in this study to satisfy municipal needs, to generate further data on a consistent province-wide basis and to assist in assessing the effectiveness of new waste management programs and identifying trends in waste composition and generation rates.

Recommendations for Further Refinement

Municipalities conducting a waste composition study might consider the following recommendations when designing the sampling protocol and implementing the study methodology.

1) For sampling and sorting convenience, municipalities may choose to conduct the waste composition studies in late spring or mid-fall when refuse odours are less intense and maggots are less frequently encountered. According to Vesling & Rimer (ref. 47), the average residential waste composition does not vary by more than +/- 10% over three quarters of the year. Therefore, aesthetics of the working conditions can be taken into account without risk to obtaining skewed data. The inclusion of yard waste in overall residential waste composition percent profiles should be avoided so that baseline composition percentages are not misrepresented.

2) Municipalities may choose to set up independent collection systems to study the seasonal generation of yard waste and leaves. This would require a coordinated effort between garbage collection personnel, private horticultural firms and other agencies generating and collecting these waste streams.

3) In order to avoid the sampling problems that we encountered with the large apartment buildings in East York, where apparent sampling biases were difficult to avoid, arrangements could be made, for example, with 30 units within the building to participate in a refuse study. This would give a more accurate appraisal of the waste composition in these large apartment buildings. As a check, the method described herein for

obtaining the per capita generation rate for the entire building could then be compared with the per capita generation rate for the 30 units.

4) Municipalities in Ontario should follow the waste composition procedure in conducting their own waste composition analysis, for reasons of consistent data generation using a cost effective approach. Periodically, municipalities should conduct additional waste composition studies to monitor trends in residential waste management and the effectiveness of waste management programs.

SECTION 1

WHY CONDUCT A WASTE GENERATION AND COMPOSITION STUDY

1.0 WHY CONDUCT A WASTE GENERATION AND COMPOSITION STUDY

The waste management challenges facing Ontario communities involve two problems:

1. The need to reduce the amount of waste entering Ontario landfills and incinerators. Many municipalities in Ontario are faced with landfills that are at or near capacity, and building new landfills is a costly and often a political and environmental challenge.

   This challenge is being met in part through the Ontario Ministry of the Environment waste diversion targets. These targets are aimed at reducing waste entering landfills by 25% by 1992, and 50% by 2001. Activities such as residential Blue Box, commercial recycling, waste composting, and recyclable material bans from landfills, and efforts to reduce waste such as excess packaging are being implemented to achieve these objectives.

2. The general societal need to reduce the amount of waste generated on a per capita basis. This need grows greater every day as renewable and non-renewable resources dwindle while population and economies continue to grow.

These two problems require careful consideration and planning by waste managers. If solutions are to be found, these managers will require reliable and current data concerning per capita waste generation rates and percent composition.

By knowing the approximate tonnages involved and the composition of the municipal waste stream, efforts can be made to maximize reduction, reuse and recycling efforts. Per capita generation rates for the total waste stream and for its component parts are needed to correctly design waste management programs and facilities.

1.1 Waste Management Planning

Waste generation information and waste composition data are required for the following reasons:

i) Quantities of waste generated in various neighbourhoods and districts within the municipality must be known to properly assign collection vehicles - therefore a per capita generation rate is needed;

ii) Proper design of waste management facilities such as transfer stations, landfills, recycling depots, composting plants and so on require information concerning the per capita generation rate and waste composition;

iii) When planning for population growth, a per capita generation rate is needed to estimate increases in total waste quantity;

iv) Waste generation rate and waste composition data are needed to assess the effects of waste diversion programs and policies.

1.1.1 Estimation of Total Waste Tonnage

A waste composition study such as the one described herein estimates tonnages of waste generated by every person in the municipality from both residential sources (Part A) and commercial sources (Part B). Waste tonnages can be estimated on a daily, weekly, monthly, or yearly basis. In addition to total tonnage generated, a waste composition study allows an estimation to be made of the tonnage of each material in the waste stream.

1.1.2 Estimation of Tonnage of Recyclable and Recoverable Material

A waste composition study allows accurate estimations to be made of the tonnages of materials being recycled by current recycling programs, the amount of material that could be recovered by those programs (capture rates), and estimates of the amount of material that could be recovered from the waste stream by additional diversion programs.

1.1.3 Estimation of Tonnage of Hazardous Materials

Of concern in the design of landfills and other waste management facilities is the amount of hazardous materials, such as paints, waste oil, used batteries, pesticides, and medical wastes that are found in the waste stream. A waste composition study will provide an estimation of the quantities of these materials present in the solid waste stream.

SECTION 2

WASTE STUDY PARAMETERS AND CONSIDERATIONS

2.0 WASTE STUDY PARAMETERS AND CONSIDERATIONS

Conducting a waste composition and generation study requires careful planning with regard to the type of data required, and how the data will be collected.

2.1 Required Waste Generation Rate and Waste Composition Data

The data collected in a waste composition study fall into two categories:

1. per capita generation rate information;
2. percent composition of the waste by component materials.

2.1.1 Waste Generation Rate

For the purposes of the Ontario Waste Composition Study the residential waste generation rate is defined as kilograms per capita per day (kg/capita/day). These units can easily be multiplied by constants to obtain weekly, monthly, or yearly generation rates in kilograms or tonnes. As well, a total tonnage of waste generated for the municipality can be calculated by multiplying by the total number of persons in the municipality by the per capita generation rate.

2.1.2 Waste Composition

The percent composition of waste by its material components is dependent on the waste stream studied, and on the definition of the categories of material used.

The waste component categories used in the Ontario Waste Composition Study were based in part on the physical or chemical make-up of the component and, in part, on the form the waste material takes. As such there are several subcategories for most materials. The subcategories could be based on physical and chemical make-up, such as those for paper (fine paper, newspaper, corrugated cardboard etc.), or the sub-categories could be based on form and usage such as with ferrous metal (food containers, returnable beverage containers, non-food containers). A list of the waste component categories and sub categories used in the Ontario Waste Composition Study is given in Table 1.

Note that in Table 1 there are no categories for bulky items such as used appliances and furniture. These items are usually collected separately from regular waste.

The category of yard waste listed in Table 1 is meant to record the quantity of yard waste co-mingled with regular waste. To assess the quantity of leaves and other yard waste collected seasonally such as during fall leaf collection programs of other spring/fall clean-ups additional data collection procedures should be used.

In addition to material composition, the Ontario Waste Composition Study also defined waste by the way in which it was collected and its subsequent destination. As such, composition of Blue Box materials, where present, are analyzed separately from the identical materials found in regular curbside waste, and yard wastes are analyzed separately from the other organic components.

2.2 Income and Housing Basis for Defining Residential Waste Generation

The Ontario Waste Composition Study used the pioneering work of Rathje et al. as a basis for designing the sampling approach and framework (ref. 4,5,6,7,8). Rathje and Thompson (1981) demonstrated during the MILWAUKEE GARBAGE PROJECT the relationship between socio-economic stratification of populations and the composition of residential refuse. Income and housing-type reflect lifestyle and as such influence waste generation.

The methodology of the Ontario Waste Composition Study used an income/housing stratification to describe discrete areas within the municipality called Census of Canada Enumeration Areas, and to select locations for the collection of waste samples.

TABLE I: WASTE COMPOSITION CATEGORIES

- (1) Paper
  - (a) Newsprint
  - (b) Fine Paper / CPO / Ledger
  - (c) Magazines / Flyers
  - (d) Waxed / Plastic / Mixed
  - (e) Boxboard
  - (f) Kraft
  - (g) Wallpaper
  - (h) OCC
  - (i) Tissues
- (2) Glass
  - (a) Beer
    - (i) refillable
    - (ii) non-refillable
  - (b) Liquor & Wine Containers
  - (c) Food Containers
  - (d) Soft Drink
    - (i) refillable
    - (ii) non-refillable
  - (e) Other Containers
  - (f) Plate
  - (g) Other
- (3) Ferrous
  - (a) Soft Drink Containers
  - (b) Food Containers
  - (c) Beer Cans
    - (i) returnable
    - (ii) non-returnable
  - (d) Aerosol Cans
  - (e) Other
- (4) Non-Ferrous
  - (a) Beer Cans
    - (i) returnable
    - (ii) non-returnable
    - (iii) American
  - (b) Soft Drink Containers
  - (c) Other Packaging
  - (d) Aluminum
  - (e) Other
- (5) Plastics
  - (a) Polyolefins
  - (b) PVC
  - (c) Polystyrene
  - (d) ABS
  - (e) PET
  - (f) Mixed Blend Plastic
  - (g) Coated Plastic
  - (i) Nylon
  - (i) Vinyl
- (6) Organic
  - (a) Food Waste / Rodent Bedding
  - (b) Yard Waste
- (7) Wood
- (8) Ceramics / Rubble / Fiberglass / Gypsum Board / Asbestos
- (9) Diapers
- (10) Textiles/Leather/Rubber
- (11) Household Hazardous Wastes
  - (a) Paints / Solvents
  - (b) Waste Oils
  - (c) Pesticides/Herbicides
- (12) Dry Cell Batteries
- (13) Kitty Litter
- (14) Medical Wastes

2.2.1 Knowing Your Community - Census Canada Information

The data required to characterize the income and housing type in a community can be obtained from Census of Canada information for the municipality. The census data is collected every five years and is available from Statistics Canada for a nominal service fee.

Census data is collected in a municipality using discreet areas mapped out by Census Canada called Enumeration Areas (EA). An enumeration area is laid out to encompass an area containing approximately 300 dwellings. As such the geographical area covered varies greatly depending on the density of housing. The EA may be a large rural area, a few city blocks, or one single highrise apartment building.

Enumeration areas were selected as the sampling frame for this study because they are the smallest statistical unit for which census data are available. As such a single EA is likely to have a relatively uniform income level and housing type. These facts allow each enumeration area to be classified into groups based on relatively distinct and real income and housing type strata.

2.2.1.1 Enumeration Areas and the Study Matrix

Census Canada reports the following data for each enumeration area within a municipality: average combine household income; the number of single detached residences, apartments, and other residences; and average number of persons per dwelling. These data are used to create a income/housing matrix for classifying all of the enumeration areas in the municipality. The matrix lay-out is shown in Table 2.

2.2.1.2 Classification of Enumeration Areas By Income

Using the most recent Statistics Canada Census data, each EA in the study community is stratified according to income level. The format for the stratification is as follows:

TABLE 2: INCOME/HOUSING MATRIX USED FOR CLASSIFYING MUNICIPAL POPULATIONS.

	Dwelling Type		
Income Level	(1) Primarily single Detached Dwellings	(2) Mixed Dwellings	(3) Primarily multiple Dwellings
(A) High	A1	A2	A3
(B) Medium	B1	B2	B3
(C) Low	C1	C2	C3

High Income:	average household income is at least 1/2 standard deviation greater than the mean income for the entire community;
Medium Income:	average household income is no more than 1/2 standard deviation greater than, or less than the mean income for the entire community;
Low Income:	average household income is at least 1/2 standard deviation less than the mean income for the entire community.

Figure 1 illustrates the concept of population stratification by income, described above.

2.2.1.3 Classification of Enumeration Areas By Housing Type

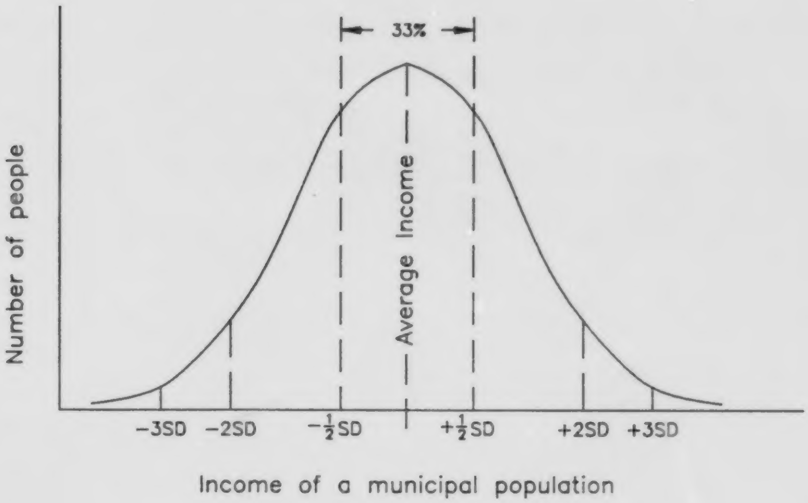
Within each income category, each EA is further classified according to housing type. For each EA, Statistics Canada reports the number of Single Detached residences, Apartments, and Other residences. These numbers, expressed as a percentage of occupied dwellings in the EA are used to identify the predominant housing type for the EA.

Primarily Single Detached:	EAs with 60% to 70% of dwellings reported as "single detached dwellings";
Primarily Multiple Dwellings:	EAs with 60% to 70% of dwellings reported as "apartments" (typically multiple story highrises).
Mixed Dwellings:	EAs with a "mixture" of single detached, apartment buildings with fewer than 30 units, and other dwelling types; having less than 60% of the dwellings listed as single detached or 60% of the dwellings listed as apartments;

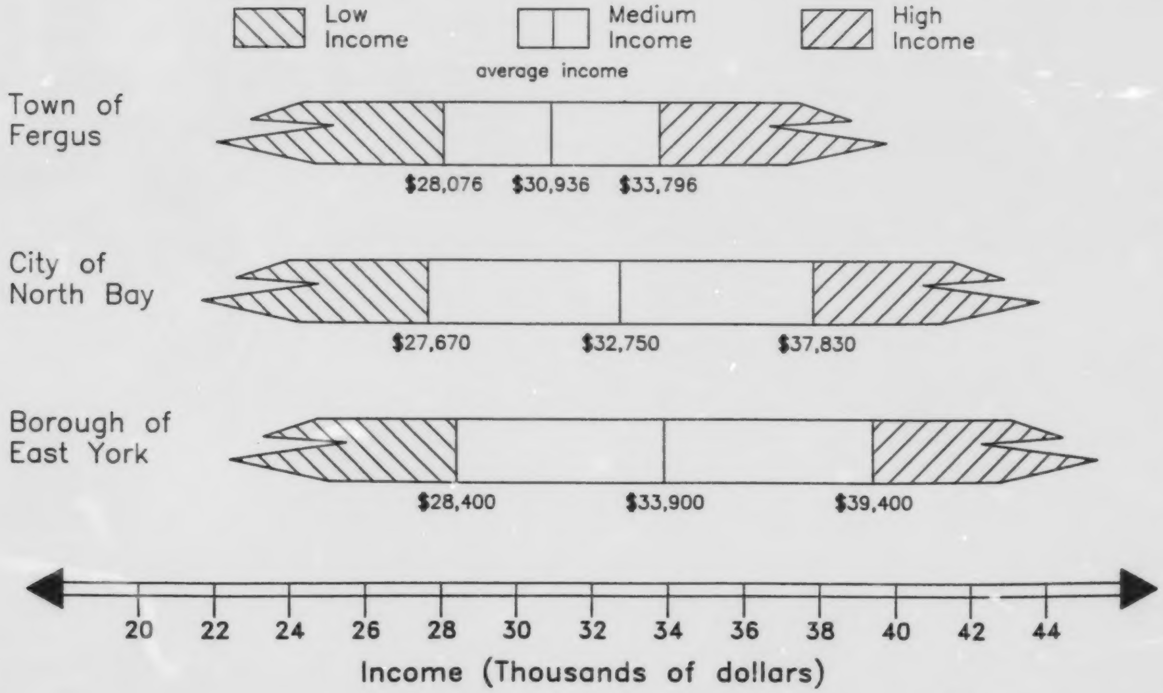
An exact boundary line between dwelling classifications is not rigorously specified in this Study because of the need for flexibility to consider the distribution of the minor components of the residential mix for a particular EA. The distribution of types of residences across the whole municipality should be examined to ensure that

FIGURE 1: CATEGORIZING A MUNICIPAL POPULATION WITH RESPECT TO INCOME:

- THEORETICAL DISTRIBUTION (1A)
- PRACTICAL APPLICATION (1B)



(1A) Idealized representation of normal income distribution over a municipal population. The middle income range extends between −1/2 SD and +1/2 SD and includes 33% of the population.



(1B) Comparison of the low, medium and high income categories for the three municipalities in the Study.

specific cells in the income/housing matrix were not grossly out of proportion to the total number of EAs or the "character" of the municipality.

Once the housing type is determined then each EA can be assigned to its respective cell in the income/housing matrix. Typically a community may have only six or seven of the nine possible income and housing types. This is expected since not all municipalities will have very large multi-story apartment building, or some housing types may not exist for given income strata.

2.2.2 Knowing Your Community - Current Waste Management Practices

The next parameter that must be known before beginning the waste study is the current waste management practices in the municipality.

The following information should be assessed:

1. waste collection frequency: once per week, or twice per week;
2. collection routes and schedules;
3. collection practices and scheduling during holidays etc.;
4. presence of Blue Box programs or other recycling activities and days on which blue box materials are collected;
5. presence of special waste collection programs such as spring and fall clean-up collections, leaf and yard-waste collections, bulky item collection days, white metal collections, hazardous waste collections and so on.

This information is needed to coordinate the collection of waste samples with regular waste collection so that conflicts do not occur, and to ensure that data are collected regarding special waste collections.

2.2.3 Effect of Seasonality On Waste Generation

In any waste composition study there is always the question of seasonality and its effect on waste composition and generation rates. There is a large body of literature (ref. 1, ref. 9) that suggests if yard waste and leaves are omitted from the calculation of composition and generation rate, the fluctuations in composition and generation rate of household waste are less than 10% over the course of the year. The methodology presented herein treats yard waste and bulky items as separate waste categories, therefore the time of year at which the waste composition study takes place is of secondary consideration. Efforts should be made, however, to assess the tonnages of leaves, yard waste and bulk items generated each year.

2.2.4 Bulk Item and Special Collection Days

Some municipalities have special collections for bulk items, spring and fall clean-up days, and leaf collection programs. These special waste streams need to be assessed individually because they do not fit into to the normal weekly generation of waste by households.

The relatively small number of samples (snap-shot approach) taken when using this methodology precludes taking of any waste that would not be generated on a daily or weekly basis. For a discussion of this problem see Volume I, Residential Waste Composition Study.

2.3 Sampling of Residential Waste

2.3.1 Number of Samples Required in Each Enumeration Area

In the three communities studied as part of the Ontario Waste Composition Study, typically six or seven EAs would be chosen for sampling, corresponding to the income/housing matrix classifications. These EAs form the sampling framework for the study.

Within each enumeration area ten (nine as a minimum) samples of regular curbside residential waste and blue box materials (where present) were taken for analysis. Nine or ten samples were required for statistically accurate results (see Volume I). This number of samples also proved to be the appropriate number for a four or five person crew to analyze in one week. This allowed the crew to study one EA per week, thus meshing with the existing collection schedules of the communities.

2.3.2 Size of Samples Required

Previous work in waste composition analysis conducted in the United States by Klee and Carruth (1971) indicated that the optimal size of each of the ten samples collected within an EA is 90-150 kilograms (200-300 pounds). As such with an EA the total weight of refuse analyzed would be approximately 1 tonne (1000 kg).

The sample weight of 90-125 kg is for regular curbside waste only. Additional collections of leaves, separated yard wastes, and bulk items will be necessary to assess the total residential waste stream. Inclusions of such materials would skew the analysis in favour of the bulky materials which may be generated infrequently over the year, and hence provide a poor representation of regular waste generation.

SECTION 3

MANPOWER, EQUIPMENT AND COST

3.0 MANPOWER, EQUIPMENT AND COST

The following is a description of the manpower requirements, necessary equipment and costs associated with conducting a waste composition study. In the manpower section a dollar value of the wage for the workers is not specified as this must be determined by the municipality conducting the study. Instead, only an estimation of the number of work days and hours required to complete the study is given. Lists of required and optional equipment is provided, but no dollar amounts for the purchase or rental of this equipment. These details should be carefully considered by any municipality undertaking a waste composition study.

3.1 Field Crew Size Requirements

Four or five people were needed for the waste collection task where a Class 1 Blue Box program exists (for example Town of Fergus; Borough of East York): two truck drivers, one collection data recorder and one (or two) people to pick up the bagged refuse and Blue Box materials. Occasionally, a 5 day work-week was not long enough to complete the collection and sorting operations and an additional work day (Saturday) was required.

In North Bay, where there was no Blue Box program in place, a three member crew carried out the refuse collection. It should be noted that the reduced crew number required that they work an extra full day, i.e., Saturdays, to complete the sorting and weighing of waste.

The field crews for the Ontario Waste Composition Study were comprised of community college students and university graduates. It was emphasized that the Study was really a "laboratory situation". Thus attention was given to organization, routine, reproducibility, consistency--even the cleanliness of garbage cans, van floor etc. This approach attempted to maximize a scientific attitude and thoughtful responsibility leading to careful work habits that the students learn as part of their analytical training. If students are not available, dedicated members of the municipal staff, or other workers could be employed.

In addition to the field crew, a project manager is required. This person must have a technical background and a high level of respect and responsibility within the municipality's works and engineering department. The project leader will be responsible (in the absence of an outside consultant) for performing the calculations necessary to define the income/housing matrix, selecting the EAs for the study, determining the sampling locations, contacting and liaisoning with waste haulers and collectors, ensuring accurate records are kept, and general management of the project.

The Project Manager will in all likelihood be required to generate a report presenting the results of the study. The amount of time required for this task will depend on the purpose for which the study was undertaken.

3.2 Equipment Requirements

The following equipment and hardware is required for the study.

3.2.1 Waste Sample Collection Equipment

The following list of equipment includes rented vehicles and purchased equipment:

one - 4.3 m.(14 ft.) cube van (for collection of bagged refuse);
one - pick-up truck (for collection of Blue Box contents);
one - electronic platform scale (150 kg capacity, Accu Weigh Model PAK-150 (electronic, battery operated scale with digital read-out), Exact Weight Scale, Inc., Toronto, Ontario);
six - 1.2 m.(4 ft.) x 1.2 m.(4 ft.) x 1.2 m. (4 ft.) heavy duty corrugated containers ("gaylords"); these containers were used for storing the bagged (non-Blue Box) refuse samples as they were being collected;
four - 1.2 m.(4 ft.) x 1.2 m.(4 ft.) divider frames (2.5 cm. x 5.1 cm. wood furring stock/chicken wire); these were used as horizontal partitions in the back of the cube van for separating the collections of bagged (non-Blue Box) refuse which were stacked on top of each other;

two - 46 cm.(18 in.) x 2.4 m.(8 ft.) divider frames (2.5 cm. x 5.1 cm. wood furring stock/chicken wire); these were used as the two main partitions in the back of the pick-up truck for segregating the collections of Blue Box materials (see Figure 2);

nine - 46 cm.(18 in.) x 41 cm.(16 in.) (approx.) plywood panels; used as partitions in the back of the pick-up truck (see Figure 2);

one - chicken wire "crib": 1.2 m.(4 ft.) x 1.2 m.(4 ft.) x 1.3 cm.(1/2 in.) plywood base; 0.6 m.(2 ft.) high chicken wire and 2.5 cm. x 5.1 cm. furring sides. Nailed to the underside of the crib floor was a square frame which permitted the crib to be centred on the bed of the platform scale (see Figure 3); the crib was used for weighing the refuse as it was being collected from curb-side;

150 - 50.8 cm.(20 in.) x 76.2 cm.(30 in.) x 6 mil polyethylene bags (Oxford Packaging Inc., Mississauga, Ontario); these were used for bagging refuse that was set out loose in garbage cans; the bags were also used for storing refuse samples for moisture and chemical analysis;

40 - 30 litre polyethylene garbage cans; these were used as containers into which sorted refuse was placed (see Figure 4);

one - 2.7 m.(9 ft.) x 3.7 m.(12 ft.) reinforced plastic tarpaulin for covering Blue Box materials in the pickup truck;

six - elastic straps to secure the tarpaulin in place;

one - broad-mouth aluminum shovel; used for cleaning up spills;

one - broom; used for cleaning up spills and sweeping out the vehicles;

one - staple gun and 0.95 cm.(3/8 in.) staples for construction and repair of chicken wire dividers and crib;

one - claw hammer; 5.1 cm.(2 in.) common nails: used in the construction of the crib and divider frames.

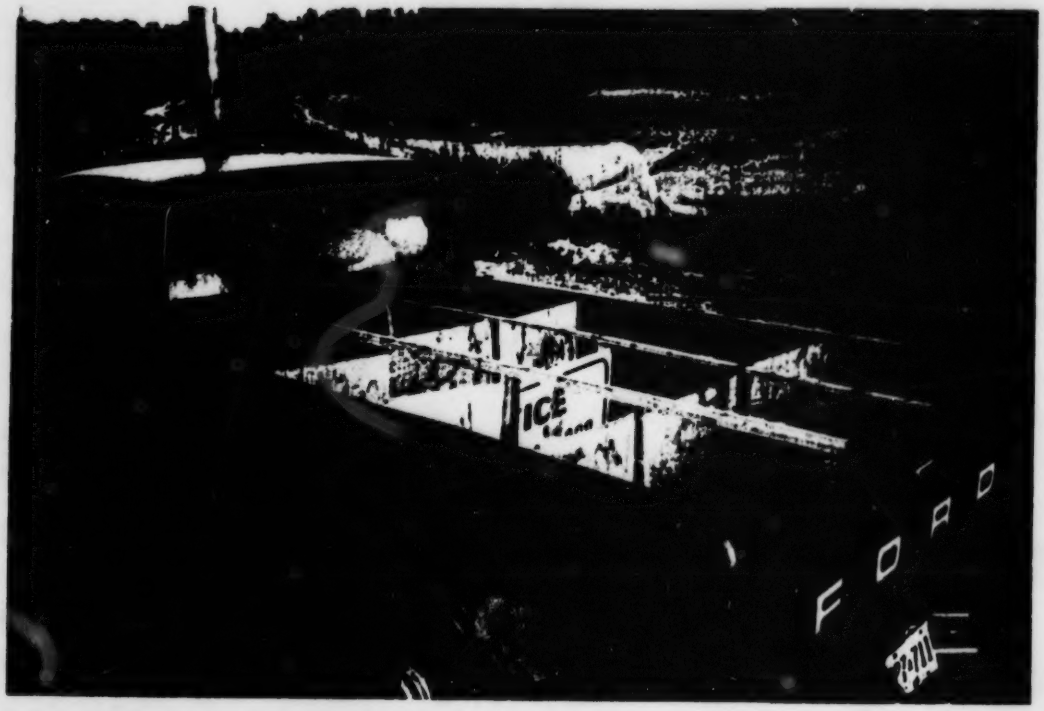


FIGURE 2: PHOTOGRAPH OF PICKUP TRUCK WITH COMPARTMENTS FOR BLUE BOX MATERIALS

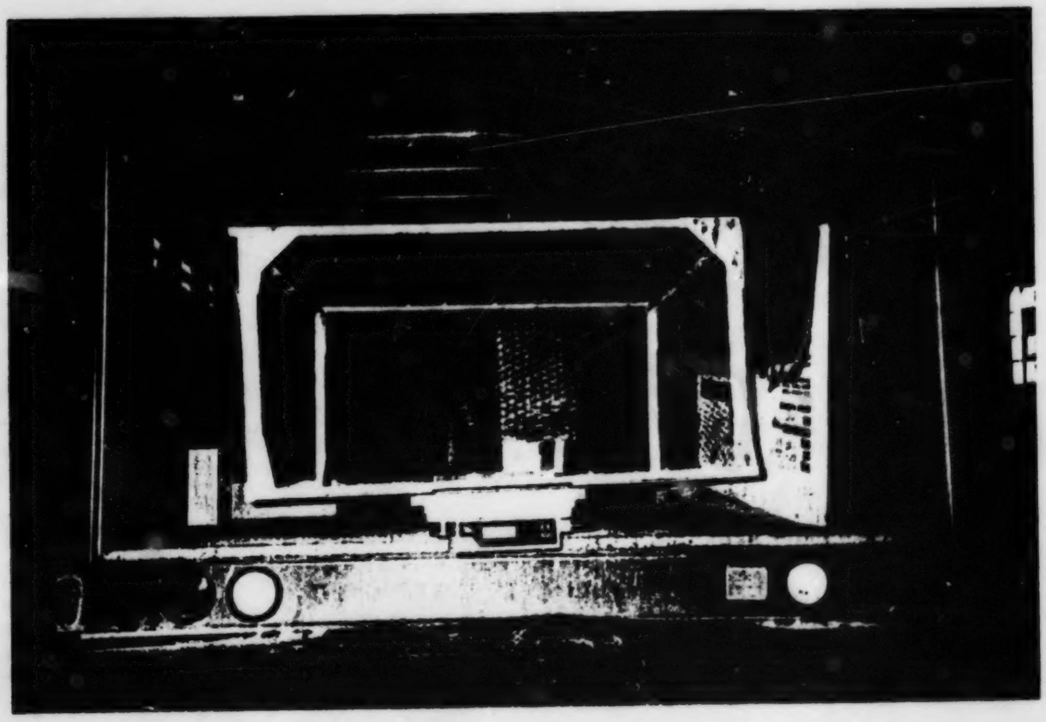


FIGURE 3: PHOTOGRAPH OF CHICKEN WIRE CRIB MOUNTED ON THE PLATFORM SCALE (REAR VIEW OF CUBE VAN)

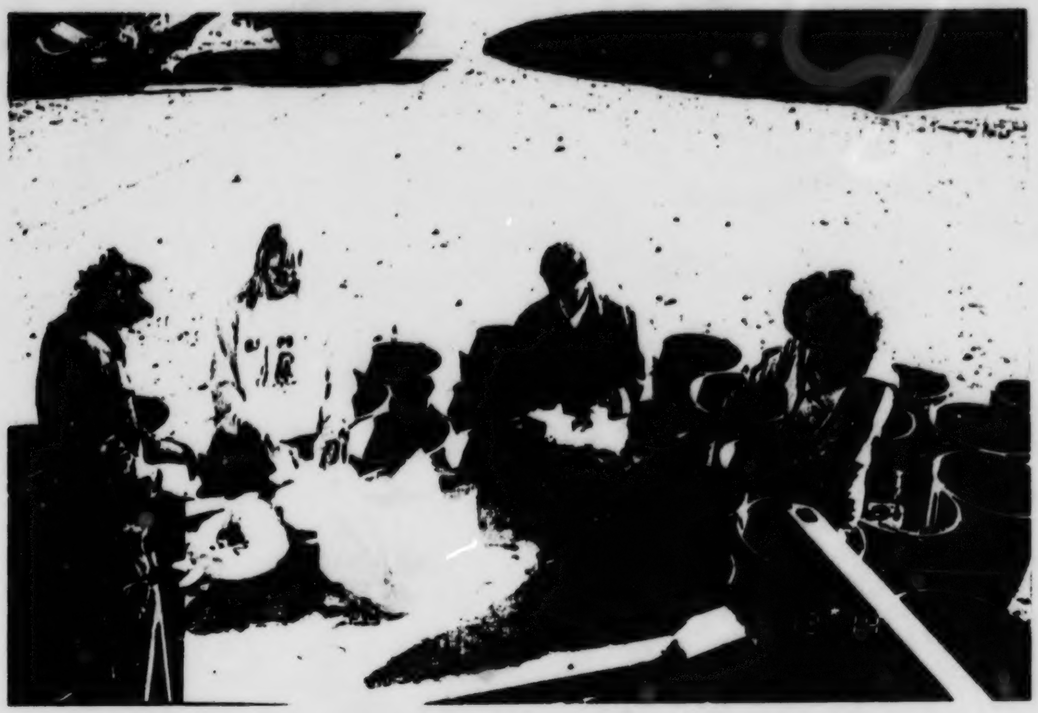


FIGURE 4: PHOTOGRAPH SHOWING THE POSITIONING OF THE STUDY TEAM AROUND THE TAILGATE SORTING TABLE

3.2.2 Waste Sample Sorting and Measurement Equipment

The following equipment and supplies were needed for the waste sorting and composition analysis:

- 1-150 kg capacity platform scale (noted previously);
- 1-5 kg capacity scale (Accurate model 5000 (electronic, battery operated with digital read-out), Exact Weight Scale Inc., Toronto, Ontario);
- 40-polyethylene garbage cans (note above);
- 1-claw hammer;
- 1-slotted screw driver;
- 1-electrician's pliers;
- 4-magnets
- pairing knives for opening plastic bags
- Personal safety equipment listed below Section 3.2.3

3.2.3 Personal Safety Equipment

Personal equipment required:

- heavy duty, waterproof (PVC-coated) gloves;
- work clothes or coveralls; rubber apron; hat (hard hat if desired)
- steel-toed work boots;
- eye protection (goggles preferable or safety glasses);
- tetanus/polio vaccination (optional: diphtheria, Hepatitis A and Hepatitis B);
- traffic safety vest;
- particle masks, worn by crew members concerned with dust and the possibility of disease transmission;
- anti-bacterial soap, used to clean gloves, hands and face before meal breaks and at the end of the day.

Safety must be stressed at all times during the study including personal hygiene. It is important to remember that within each bag of garbage there may be disease carrying organisms, sharp objects including hypodermic needles, containers that may explode, combustibles, corrosive and caustic agents, harmful chemicals, and dust.

3.2.4 Seasonal Effects on Equipment Requirements - Shelter and Clothing

The season of the year in which the study is conducted has a great bearing on the clothing and shelter requirements of the field crew, and general carrying out of the study.

For several reasons it may be advisable to conduct the study during the fall or winter months. The waste will have less odour and fewer maggots and flies at this time of year. In addition the cool or freezing temperatures will keep the organic fraction of the waste from rotting which will makes the work more manageable from an objective and aesthetic standpoint. The cooler weather will also reduce the amount of moisture lost by the waste, due to evaporation, from the time the sample is collected to the time it is actually sorted (several days in some cases).

If the study is conducted in the autumn or winter months some form of shelter is required by the field crew while sorting the waste. Shelter is required to protect the field crew (and the waste samples!) from wind, rain, snow and cold. During the Ontario Waste Composition Study the following locations were used during the fall and winter study periods. In the Borough of East York, the tipping floor of the former Commissioners Street Incinerator was used. When this location became too cold in December, the sorting location was moved into a heated workshop adjacent to the tipping floor. In North Bay sorting was conducted in a large carnival tent. Heating in the tent was supplied by propane heaters.

In the summer protection from the wind, rain, and direct sun will be required.

In addition to a sheltered work space, the sorting crew must be provided with a warm, dry break-room, and washroom facilities.

3.3 Cost of Conducting a Typical Waste Study

The following is an estimate of the cost associated with conducting a waste composition study.

The length of time required to conduct the residential phase of the waste study is dependent on the number of EAs identified in the income/housing matrix. At most there will be nine EAs to study, although most communities will have fewer since not all cells of the matrix will have representative EAs. In addition to the nine (maximum) EAs identified in the matrix, additional EAs may be studied to confirm the results from the other EAs. Each EA studied requires one week (5-6 days) to complete the sample collection and sorting.

3.3.1 Anticipated Personnel Time Requirements and Costs

STAGE 1: PROJECT INITIATION AND CLASSIFICATION OF ENUMERATION AREAS INTO AN INCOME/HOUSING MATRIX

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Project Initiation	Project Manager[1]	3.0
Task: Obtaining Census Data from Statistics Canada Archive Libraries	Project Manager Project Assistant[2]	1.0 1.0
Task: EA Classification by Income/Housing Types	Project Manager	1.0
Task: Selection of EAs for Inclusion in the Study (Matrix Classification allows for 9 EAs. More may be included in the study as required)	Project Manager	2.25 (0.25 days/EA)
SUB TOTAL:	Project Manager Project Assistant	7.75 1.0
COSTS:	Statistics Canada Service Fee for Materials Travel, Telephone Use, Office Supplies, Computer Time	

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[1] The Project Manager will typically be a person from the Municipal Engineering Department or some other member of the Municipal Staff familiar with Waste Management procedures.

[2] The Project Assistant would ideally be a member of the field crew and also a member of the municipal staff familiar with waste management procedures.

3.3.1 Anticipated Personnel Time Requirements and Costs Continued

STAGE 2: DETERMINING SAMPLE POINTS WITHIN THE CHOSEN ENUMERATION AREAS

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Determining Sample Points Within the Selected Study EAs.	Project Manager Project Assistant	4.5 (0.5 days/EA) 2.25 (0.25 days/EA)
SUB TOTAL:	Project Manager Project Assistant	4.5 2.25

COSTS: Travel (inspection of EAs required), Telephone Use, Office Supplies

Stage 1 and Stage 2 can be carried out by the Project Manager, or in association with an outside consulting agency familiar with Census of Canada data and sampling procedures.

3.3.1 Anticipated Personnel Time Requirements and Costs Continued

STAGE 3: COLLECTION OF RESIDENTIAL WASTE SAMPLES

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Obtaining/Constructing All Required Equipment and Supplies (See Section 3.2)	Project Manager Project Assistant	3 3
Task: Contacting Municipal/Private Waste Haulers; Contacting Apartment Building Managers; Contacting Other Officials as Required (See Section 6.6)	Project Manager	0.5 days/EA
(A) Once per week municipal waste collection Task: Collection of Waste Sample	Project Manager Field Crew[3]	0.5 days/EA 0.5 days/EA x 4 Persons
(B) Twice per week municipal waste collection Task: Collection of Waste Sample	Project Manager Field Crew	1.0 days/EA 1.0 days/EA x 4 Persons
SUB TOTAL:	Project Manager	3.0 days
(A) Once per week waste collection		
	Project Manager	1.0 days/EA (Field Work)
	Field Crew	0.5 days/EA
(B) Twice per week waste collection		
	Project Manager	1.5 days/EA (Field Work)
	Field Crew	1.0 days/EA
	Project Assistant	2.0

---

[3] The four (4) person field crew would ideally be composed of persons dedicated to the study and familiar with waste management procedures, and aware of the need for accurate waste management information. The field crew members should have some education in standard laboratory skills such as proper use of scales, accurate record keeping and the necessity of replication of study results. The 4 person field crew may include the project assistant, who could act as a supervisor in the absence of the Project Manager.

3.3.1 Anticipated Personnel Time Requirements and Costs Continued

STAGE 4: WASTE SORTING AND ANALYSIS

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Field Crew Training - Sorting and Classifying Waste; Data Recording Procedures; Safety	Project Manager	2.0
	Field Crew	1.0 x 4 persons
Task: Waste Sorting	Project Manager	1.0 day/EA
	Field Crew	5.0 days/EA x 4
SUB TOTAL:	Project Manager	2.0 (training)
	Project Manager	1.0 day/EA (field work)
	Field Crew	1.0 (training)
	Field Crew	5.0 days/EA (field work)

COSTS: Equipment purchases and rentals including obtaining shelter for the field crew, provision of safety equipment, and tetanus/polio/diphtheria immunization of the field crew (see Section 3.2) Tipping/disposal fee for sorted waste after analysis Telephone Use, Travel Cost, Office Supplies

Additional Costs associated with optional laboratory analyses such as heating value (BTU) analysis, moisture content and leachable metal content should be included in budget calculation.

Additional time should be allocated for the collection and analysis of yard waste/leaves, white metal goods, and other bulk items. Requirements for a field crew will vary between municipalities and study approaches taken. See section 6.3 and 6.4 for a discussion of approaches to analyzing these waste streams.

3.3.1 Anticipated Personnel Time Requirements and Costs Continued

STAGE 5: DATA ANALYSIS AND REPORT WRITING

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Data Entry to Spreadsheets	Project Assistant	1.0 day/EA
Task: Data Analysis, Calculations and Report Writing	Project Manager	10.0
	Project Assistant	3.0
SUB TOTAL:	Project Manager	10.0
	Project Assistant	1.0 days/EA (data entry)
	Project Assistant	3.0 (clerical)
COSTS:	Office Supplies, Computer Time	

WORK DAYS TOTAL

Administrative:	Project Manager	26.25
	Project Assistant	9.25
Training Period:	Project Manager	2.0
	Field Crew	1.0 x 4
Field Work:		
(A) Once per week waste collection		
	Project Manager	2.0 days/EA
	Field Crew	5.5 days/EA x 4
(B) Twice per week waste collection		
	Project Manager	2.5 days/EA
	Field Crew	6.0 days/EA x 4

SECTION 4

STAGE 1 - DEFINING THE INCOME/HOUSING TYPE MATRIX

4.0 STAGE 1 - DEFINING THE INCOME/HOUSING MATRIX

As outlined above, the first task of the study is to classify all of the enumeration areas in the study areas (EAs) according to the income/housing matrix. This task defines the sampling framework for the study. The EAs that will be sampled are selected from the matrix cells corresponding to each of the nine possible income and housing types.

4.1 Obtaining Statistics Canada Data

Statistics Canada census data needed for this study can be obtained from the following Statistics Canada library:

Statistics Canada, Toronto
Telephone number:(416) 973-6586
Address: 25 St. Clair Ave. East
Toronto, Ontario
M4T 1M4

Data can be obtained in a printed format or on computer disk or tape. Larger municipalities may find the computer disk format more useful owing to the large volume of data required.

4.2 Municipal Income Stratification

Using the most recent Statistics Canada Census data available, each EA in the study municipality is stratified according to income level. The format for the stratification is:

High Income: average household income is at least 1/2 standard deviation greater than the mean income for the entire community;

Medium Income: average household income is no more than 1/2 standard deviation greater than, or less than the mean income for the entire community;

Low Income: average household income is at least 1/2 standard deviation less than the mean income for the entire community.

To carry-out the classification by income it is necessary to perform the following calculations:

1. calculate the overall mean household income of all EAs in the municipality;
2. calculate the standard deviation of household incomes from the overall mean household income
3. Subtract the average household income for each EA from the overall mean household income for the municipality.
4. Divide the difference of the two means by the standard deviation to determine the number of standard deviations away from the overall mean.

4.2.1 Anytown: Stratifying Income Levels

The stratification of income levels in the fictional town of Anytown is presented in Table 3.

The example classification of EAs in Anytown by income level demonstrates the relationship between the reported average combined household income, the mean household income for the municipality, and the half standard deviation measure.

TABLE 3: ANYTOWN: CLASSIFYING ENUMERATION AREAS BY INCOME LEVEL

ENUMERATION AREA	AVERAGE COMBINED HOUSEHOLD INCOME IN EACH EA	STANDARD DEVIATIONS FROM THE MEAN	CLASSIFICATION
101	$26,010	-0.83	LOW INCOME
102	$22,371	-1.26	LOW INCOME
103	$29,786	-0.38	LOW INCOME
104	$31,851	-0.15	MEDIUM INCOME
105	$34,739	+0.20	MEDIUM INCOME
106	$31,957	-0.13	MEDIUM INCOME
107	$49,655	+1.96	HIGH INCOME
108	$45,726	+1.50	HIGH INCOME
109	$22,246	-1.27	LOW INCOME
110	$35,482	+0.29	MEDIUM INCOME
111	$31,920	-0.13	MEDIUM INCOME
112	$36,728	+0.43	MEDIUM INCOME
113	$31,746	-0.15	MEDIUM INCOME
114	$41,640	+1.01	HIGH INCOME
115	$36,741	+0.44	MEDIUM INCOME

Mean Income of all Enumeration Areas:	$33,906
Standard Deviation of the Mean Income:	7446
Half of the Standard Deviation:	3723

4.3 Municipal Housing Type Characteristics

Each EA is further classified according to housing type. Statistics Canada reports the number of Single Detached residences, Apartments, and Other residences in each EA. These numbers, expressed as a percentage of occupied dwellings in the EA are used to identify the predominant housing type for the EA.

Primarily Single Detached:	EAs with 60% to 70% of dwellings reported as single detached;
Primarily Multiple Dwellings:	EAs with 60% to 70% of dwellings reported as "apartments".
Mixed Dwellings:	EAs with a mixture of single detached, apartment buildings with fewer than 30 units, and "other" dwelling types;

An exact boundary line between dwelling classifications is not rigorously specified in this Study because of the need for flexibility to consider the distribution of the minor components of the residential mix for a particular EA. The distribution of types of residences across the whole municipality should be examined to ensure that specific cells in the income/housing matrix were not grossly out of proportion to the total number of EAs.

4.3.1 Anytown: Classifying Housing Type

The Classification of Housing Type in the fictional town of Anytown is presented in Table 4.

The example classification of EAs in Anytown by housing type level demonstrates the relationship between the percentage of dwelling reported in each of the categories: single detached dwellings, apartments, and other dwellings.

TABLE 4: ANYTOWN: CLASSIFYING ENUMERATION AREAS BY HOUSING TYPE

ENUMERATION AREA	TOTAL OCCUPIED DWELLINGS	NUMBER OF SINGLE DETACHED HOUSES	NUMBER OF APARTMENTS	NUMBER OF OTHER DWELLINGS	CLASSIFICATION
101	305	30 (10%)	200 (66%)	75 (25%)	MULTIPLE DWELLINGS
102	335	10 (3%)	195 (58%)	130 (39%)	MIXED DWELLINGS
103	345	145 (42%)	90 (26%)	110 (32%)	MIXED DWELLINGS
104	240	200 (83%)	5 (2%)	35 (15%)	SINGLE DETACHED
105	345	140 (41%)	0 (0%)	205 (59%)	MIXED DWELLINGS
106	220	0 (0%)	215 (98%)	5 (2%)	MULTIPLE DWELLINGS
107	360	360 (100%)	0 (0%)	0 (0%)	SINGLE DETACHED
108	225	0 (0%)	225 (100%)	0 (0%)	MULTIPLE DWELLINGS
109	325	130 (40%)	80 (25%)	115 (35%)	MIXED DWELLINGS
110	370	350 (95%)	0 (0%)	20 (5%)	SINGLE DETACHED
111	335	190 (57%)	0 (0%)	145 (43%)	MIXED DWELLINGS
112	175	0 (0%)	175 (100%)	0 (0%)	MULTIPLE DWELLINGS
113	220	220 (100%)	0 (0%)	0 (0%)	SINGLE DETACHED
114	300	215 (72%)	0 (0%)	85 (28%)	SINGLE DETACHED
115	325	290 (89%)	10 (3%)	25 (8%)	SINGLE DETACHED

4.4 Allocating Individual EAs to the Matrix Cells

Once each EA has been classified according the relative income level and predominant housing type, the EAs are assigned to the income housing matrix cell they correspond to. This can best be done by sorting the EAs according to their income classification (high, medium, low). Then within each income class sort the EAs according to their housing type classification.

4.4.1 Anytown: Allocating Individual EAs to Matrix Cells

In the example for the fictional town of Anytown, the income/housing classification is shown in Table 5. The matrix cells corresponding to the classifications of High income/Mixed Dwellings, and Low Income/Single Detached Dwellings are not represented. It is not unusual for a municipality to lack representation in one or more matrix cells.

The number of EAs in each classification will be needed for the calculation of the per capita generation rates during the data analysis stage of the study.

4.5 Selecting the Study EAs

Once all of the EAs have been classified it is a simple procedure to select the EAs for inclusion in the study. The EAs should be selected at random, using a random number table where more than one EA is present in a given Matrix cell.

4.5.1 Anytown: Selecting the Study EAs

The classification of EAs in the fictional town of Anytown revealed that the following classes had more than one EA assigned to them: high income/single detached dwellings, medium income/single detached dwellings; medium income/mixed dwellings; medium income/multiple dwellings; low income/ mixed dwellings. From these groups only one EA per classification is needed for the study.

TABLE 5: ANYTOWN: ALLOCATING INDIVIDUAL ENUMERATION AREAS TO THE INCOME/HOUSING MATRIX CELLS

ENUMERATION AREA	INCOME / HOUSING CLASSIFICATION
107	HIGH INCOME / SINGLE DETACHED DWELLINGS
114	HIGH INCOME / SINGLE DETACHED DWELLINGS
---	HIGH INCOME / MIXED DWELLINGS
108	HIGH INCOME / MULTIPLE DWELLINGS
104	MEDIUM INCOME / SINGLE DETACHED DWELLINGS
110	MEDIUM INCOME / SINGLE DETACHED DWELLINGS
113	MEDIUM INCOME / SINGLE DETACHED DWELLINGS
115	MEDIUM INCOME / SINGLE DETACHED DWELLINGS
103	LOW INCOME / MIXED DWELLINGS
105	MEDIUM INCOME / MIXED DWELLINGS
111	MEDIUM INCOME / MIXED DWELLINGS
106	MEDIUM INCOME / MULTIPLE DWELLINGS
112	MEDIUM INCOME / MULTIPLE DWELLINGS
---	LOW INCOME / SINGLE DETACHED DWELLINGS
102	LOW INCOME / MIXED DWELLINGS
109	LOW INCOME / MIXED DWELLINGS
101	LOW INCOME / MULTIPLE DWELLINGS

To randomly select the EAs to be used in the study, assign each of the EAs a number. From the random number table select a number for each classification and use the EA with the corresponding number for the study. Table 6 provides an example of how to randomly select enumeration areas for inclusion in the study from a list of several enumeration areas that may fall within a single classification.

Note that for the classification Medium Income/Mixed Dwellings the random numbers 7 and 9 correspond to Enumeration Areas 103 and 111. Either enumeration area could be chosen but by convention the first (random number 7, EA 103) would be used for the study.

TABLE 6: ANYTOWN: RANDOMLY SELECTING ENUMERATION AREAS TO BE INCLUDED IN THE WASTE COMPOSITION STUDY

CLASSIFICATION	ENUMERATION AREA	ASSIGNED NUMBER	SELECTED
HIGH INCOME /	107	1	
SINGLE DETACHED DWELLINGS	114	2	YES
MEDIUM INCOME /	104	3	
SINGLE DETACHED DWELLINGS	110	4	
	113	5	
	115	6	YES
MEDIUM INCOME /	105	7	YES
MIXED DWELLINGS	111	8	
MEDIUM INCOME /	106	9	YES
MULTIPLE DWELLINGS	112	10	
LOW INCOME /	102	11	YES
MIXED DWELLINGS	103	12	
	109	13	YES

RANDOM NUMBERS: 2, 7, 9, 11, 6, 13

All other income/housing classifications had one or less enumeration areas assigned to them, and therefore were automatically selected for use in the waste composition study.

SECTION 5

STAGE 2 - SELECTING SAMPLE POINTS WITHIN AN EA

5.0 STAGE 2 - SELECTING SAMPLE POINTS WITHIN AN EA

In Stage 1 the municipality or study area was characterized by enumeration area using an income/housing matrix. From the matrix of income and housing types, one enumeration area per matrix cell was selected at random for study.

Within each chosen EA ten (nine as a minimum) samples must be collected. These samples should be taken so that the samples collected are evenly spread over the entire EA. In addition every household in the EA must have an equal chance of being included in the study.

To achieve these goals ten collection starting points are selected in the EA using a random method. Samples are collected from every house encountered with waste set out for collection while driving along the street(s) containing the starting point until approximately 100 kg of waste is taken. Following the collection of the first 100 kg sample the crew moves on to the next starting point and collects the next 100 kg sample. The process continues until all ten samples have been collected.

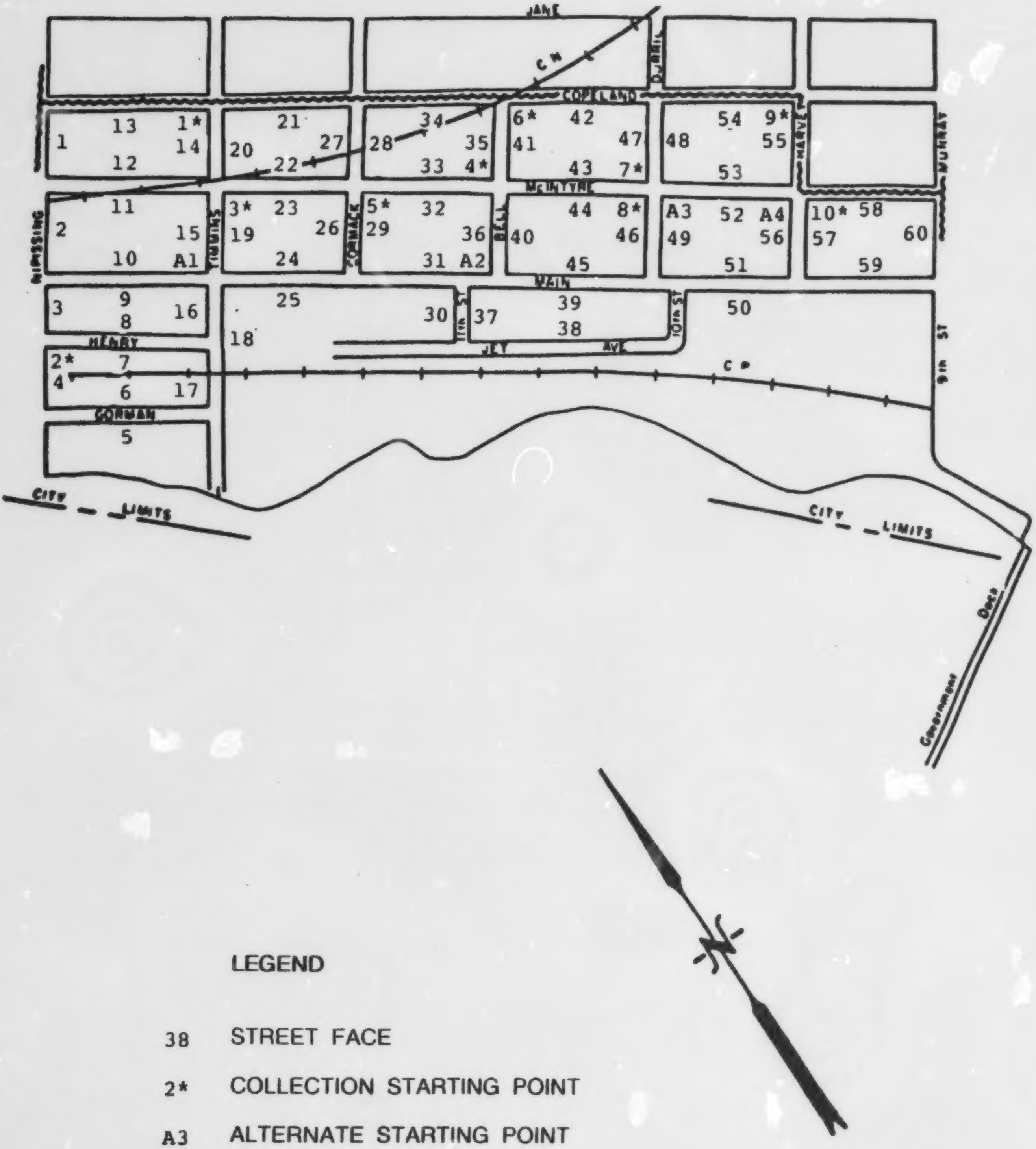
5.1 Street Face Numbering

The first step in selecting the sampling start points is to number each street face in the EA.

By convention, during the Ontario Waste Composition Study, this numbering started in the upper left corner of the EA map (see example Figure 5) and proceeded down and up the page, moving left to right, to the bottom right corner. Every street face was given an individual number.

In addition to the identification of street face starting points, large apartment buildings (10 or more units) in the mixed housing classification should be identified if they exist. These buildings are given a number, like a street face, and may be selected as a sampling location. Buildings of this size will usually generate more than enough waste for one sample.

FIGURE 5: EXAMPLE OF ONE EA SHOWING NUMBERING OF BLOCK FACES AND SAMPLE COLLECTION "STARTING POINTS"


JANE
CN
COPELAND
DURRIL
HARVE
MURRAY
McINTYRE
NIPISSING
TIMMINS
CORMACK
BELL
MAIN
11th ST
10th ST
JET AVE
HENRY
GORMAN
CP
9th ST
CITY LIMITS
CITY LIMITS
Government Dock
N
1 13 1* 14 12
20 21 27 22
28 34 35 33 4*
6* 42 41 47 43 7*
48 54 9* 55 53
2 11 15 10 A1
3* 23 19 26 24
5* 32 29 36 31 A2
40 44 8* 46 45
A3 52 A4 49 56 51
10* 58 57 60 59
3 9 8 16
25 18 30
37 39 38
50
2* 7 4 6 17
5

LEGEND

38	STREET FACE
2*	COLLECTION STARTING POINT
A3	ALTERNATE STARTING POINT

5.2 Random Selection of Starting Points

Using a random number table ten staring points where selected. By convention collection would start on the street face selected at the eastern, or northern end of the street. In addition to the ten start points selected, three or four alternate start points would also be identified. The need for alternate starting point will be discussed in STAGE 3 - Collection of Waste Samples.

SECTION 6

STAGE 3 -COLLECTION OF WASTE SAMPLE

6.0 STAGE 3 - COLLECTION OF WASTE SAMPLE

Stage 1 described the method used to classify each of the EAs in the municipality, and described the method for selecting EAs to be used in the study. Stage 2 described the method of determining where in the study EAs the samples would be taken from, and outlined the number and size of samples to be taken.

Stage 3 describes in detail the actual sampling of residential waste. Each of the housing types used in the classification of EAs typically has different waste set out practices and collection procedures. These differences require slightly different waste sample collection procedures.

6.1 Regular Curbside Waste

Waste from single detached dwellings, duplexes, houses with apartments, and small apartment buildings is usually set out at the curb by the occupants for collection by the municipal garbage collection brigade. The waste will typically be set out in plastic bags or garbage pails. In addition to regular waste there may be Blue Box Materials, bundles of yard waste, bags of leaves, and items too bulky to be bagged or put in a garbage pail.

6.1.1 Waste Collection Process: Detached Dwellings--General Procedures

The goal of the waste collection process, on any one day, was to obtain 10 (9 as a minimum), 100 kg (minimum weight) samples of residential waste--exclusive of the weight of Blue Box materials and yard waste that were also coincidentally collected if they were placed curbside. This task proceeded as quickly as possible, with a 0700 h start, so that the normal collection of waste and Blue Box items by the municipality was not seriously inconvenienced.

The waste sample collection began at one of the starting points (refer to Figure 5). Waste was collected in front of every dwelling where it was set out, until approximately 100 kg were accumulated in the crib (see Figure 3), some variations to this are noted below. An "en route" collection record was kept of the number of dwellings that had waste set out: general waste and/or Blue Boxes. Single and duplex dwellings were also indicated.

The importance of the "en route" collection record and the accuracy of the recording of the number of dwellings that were sampled should be noted. The team member who recorded the trip data did not have time to concentrate on any other aspect of the curb-side collection process.

Loose waste set out in garbage cans was rebagged in clear polyethylene bags. These bags were reused and not included in the analyzed waste sample. The collected waste was placed in the chicken wire crib which was mounted on the platform scale on the floor of the van (see Figure 3). The scale was tared with the empty crib on it, prior to filling the crib with waste. When the minimum required weight of waste had been collected (with an allowance for the estimated inclusions of yard waste co-disposed with household waste), the crib was unloaded and the sample was stored in the van. Samples were collected such that no waste was left at the curb.

Corrugated gaylords were used to store six of the waste collections. Two of the remaining collections were piled on top of 1.2 m (4 ft.) x 1.2 m (4 ft.) chicken wire dividers placed on top of the collections in the gaylords. The ninth collection of bagged refuse was piled on top of the Blue Box materials, stored in compartments in the pick-up truck (see below), while the tenth collection was kept in the weighing crib.

Yard waste set out at the curb was weighed at the time of sample collection. The weight was recorded and the yard waste was placed back at the curb for municipal waste collection.

Blue Box items were placed in the corresponding sample compartment in the back of the pick-up truck (Figure 4). There was space for 9 collections in the truck; the tenth collection was stored in polyethylene garbage cans in the van.

It took between 2 and 2.5 hours to make 9-10 collections within an EA. Following the last collection, the contents in the pick-up truck were covered with a tarpaulin.

Elastic straps secured the crib and contents in the back of the van. The Study team proceeded to the base of operations in the municipality and began sorting the samples.

6.1.2 Required Number of Samples

As described above, ten samples (nine as a minimum) are required from each EA. If for various reasons fewer than ten samples are taken, the results for the EA with fewer than ten samples will be reliable but less accurate.

6.1.3 Required Weight of Each Sample

Each of the ten samples taken should weigh 90-125 kg (200-300 lbs). A target weight of 100 kg should be made for each sample with the bias toward larger samples rather than smaller samples. If, for instance, 95 kg of waste have been collected and the next house on the collection route has 10 to 15 kg of waste (typical weight) then that waste should also be taken to guard against weighing errors, loss of materials later on, or other factors which could reduce the weight of that sample.

6.1.4 Collection Equipment Requirements

The following list of equipment includes rented vehicles and purchased equipment:

one - 4.3 m (14 ft.) cube van (for collection of bagged refuse);
one - pick-up truck (for collection of Blue Box contents);
one - electronic platform scale (150 kg capacity, Accu Weigh Model PAK-150 (electronic, battery operated scale with digital read-out), Exact Weight Scale, Inc., Toronto, Ontario);
six - 1.2 m (4 ft.) x 1.2 m (4 ft.) x 1.2 m (4 ft.) heavy duty corrugated containers ("gaylords"); these containers were used for storing the bagged (non-Blue Box) refuse samples as they were being collected;
four - 1.2 m (4 ft.) x 1.2 m (4 ft.) divider frames (2.5 cm x 5.1 cm wood furring stock/chicken wire); these were used as horizontal partitions in

the back of the cube van for separating the collections of bagged (non-Blue Box) refuse which were stacked on top of each other;

two - 46 cm (18 in.) x 2.4 m (8 ft.) divider frames (2.5 cm x 5.1 cm wood furring stock/chicken wire); these were used as the two main partitions in the back of the pick-up truck for segregating the collections of Blue Box materials (see Figure 2);

nine - 46 cm (18 in.) x 41 cm (16 in.) (approx.) plywood panels; used as partitions in the back of the pick-up truck (see Figure 2);

one - chicken wire "crib": 1.2 m (4 ft.) x 1.2 m (4 ft.) x 1.3 cm (1/2 in.) plywood base; 0.6 m (2 ft.) high chicken wire and 2.5 cm x 5.1 cm furring sides. Nailed to the underside of the crib floor was a square frame which permitted the crib to be centred on the bed of the platform scale (see Figure 3); the crib was used for weighing the refuse as it was being collected from curb-side;

150 - 50.8 cm (20 in.) x 76.2 cm (30 in.) x 6 mil polyethylene bags (Oxford Packaging Inc., Mississauga, Ontario); these were used for bagging refuse that was set out loose in garbage cans; the bags were also used for storing refuse samples for moisture and chemical analysis;

40 - 30 litre polyethylene garbage cans; these were used as containers into which sorted refuse was placed (see Figure 4);

one - 2.7 m (9 ft.) x 3.7 m (12 ft.) reinforced plastic tarpaulin for covering Blue Box materials in the pickup truck;

six - elastic straps to secure the tarpaulin in place;

one - broad-mouth aluminum shovel; used for cleaning up spills;

one - broom; used for cleaning up spills and sweeping out the vehicles;

one - staple gun and 0.95 cm (3/8 in.) staples for construction and repair of chicken wire dividers and crib;

one - claw hammer; 5.1 cm (2 in.) common nails: used in the construction of the crib and divider frames.

6.1.5 Twice Weekly Garbage Collection Sampling Protocol

Some municipalities will have twice weekly collection of garbage. In these communities it will be necessary to collect samples on both collection days since the waste sample must reflect the waste generation characteristics of the enumeration area for the entire week. This presents some problems during sample collection in that a decision must be made regarding the weight of waste to be taken on each sample day.

As an example of this problem staff in the Borough of East York indicated that about 60% of the weekly volume of refuse was placed at curb-side for the first of the two weekly collections, with about 40% set out for the second collection. This ratio was not universally reliable for all of the EAs in the Borough. With a target of 100 kg (minimum weight) of waste that had to be collected for a sample of adequate size, the following collection protocol was developed and illustrated in the example below.

For a given sample, approximately 60 kg of bagged refuse was collected, for example, from 7 houses on the first collection day. Sample collection on the second day started from the same "starting point" assigned on the first day and waste was collected from the same number of dwellings. In theory, the 60/40 relationship would result in approximately 40 kg of refuse collected on the second collection day, for total of 100 kg of waste for the composition analysis.

It is absolutely imperative that waste be collected from the same number of dwellings on the second collection day. Calculation of the per capita generation rate is dependent on knowing the number of dwellings waste was collected from (and average number of occupants per dwelling), and the total weight of refuse collected.

The uncertainty of the 60/40 ratio, required the collection crew to "overcompensate" the weight of the first collection in each sample by picking up more than 60 kg, e.g., 70 kg. This "insurance" weight meant that the crew was required to pick up from 7 dwellings on the second collection day. The sum of two collections would not likely be less than 100 kg.

There were instances in East York where the 60/40 relationship was not accurate. This resulted in either less than 100 kg of waste being collected for the week or a weight greatly in excess of 100 kg being collected. Neither of these occurrences is of great concern so long as they occur infrequently.

Waste collection from apartment buildings with twice weekly collection did not present this kind of a sampling problem (see below).

6.1.6 Recording Number of Houses Passed and Weight of Sample

As note previously, one member of the collection team was assigned the duty of recording information as the sample collection proceeded. The collection record is extremely important later when the per capita generation rate is being calculated.

The sample collection notes must accurately record:
1. Date and time of collection
2. Enumeration area sample
3. Address of "starting point" for each sample
4. Number of houses waste was taken from
5. Number of houses Blue Box materials were collected from
6. Weather conditions (e.g. rain that would wet the sample)

6.2 Blue Box Materials

Blue Box materials are collected along with regular waste, but their weight is not included (initially) in the 100 kg sample taken. Samples of Blue Box materials were stored in the back of the pick-up truck in the compartments constructed out of wood and chicken wire (Figure 2). The number of dwellings setting out Blue Boxes was often different from the number of dwellings regular waste was collected from. It is important to record the number of dwellings blue box materials were collected from for later use in calculating the per capita generation rate and "capture rate" of Blue Box materials.

6.3 Yard Waste and Seasonality

Residential waste from detached dwellings usually contains a certain amount of yard waste (e.g., leaves, grass clippings, brush, etc.) This material can represent a significant proportion of the waste at certain times of the year. The amount of yard waste will typically be very high in the spring and fall during yard clean-up times, and may also be high during the summer grass growing and gardening times. During the rest of the year very little yard waste is generated.

In a study designed to analyze the composition of residential waste by taking a limited number of samples, it is suggested that yard waste be excluded from the calculation of per capita generation rates and percent composition of residential waste. Depending on the exact time of the study, yard waste may represent too large or too small a proportion of the yearly average generation rate for the municipality. Yard waste generation rates require a long term (yearly) monitoring program to accurately describe their generation rate.

6.3.1 Collection and Analysis of Yard Waste

During collection of residential waste samples, yard waste may be encountered. Where possible, yard waste should be separated at the curbside, weighed, its weight recorded, and returned to the curb. The weight of yard waste should not be included in the 100 kg sample. Bags of refuse suspected of being entirely yard waste should be opened and examined during the collection process. The weight of yard waste is recorded on the composition data sheets but is not included in the per capita generation rate calculation for the reasons stated above.

On occasion yard waste will go undetected at the curbside or is commingled with regular waste. The weight of this material should be recorded at the time of sorting, but will not be used in the calculation of per capita generation rates or percent composition.

6.4 Large and Bulk Items

Large and bulk items present a problem for the sample collection and data analysis. Often a large or heavy item(s) will be placed at the curbside with the regular waste. These heavy items will have the effect of increasing the percent composition of the waste sample toward material component of the large item, and lowering the other material component percentages. Large heavy items that are clearly not part of the regular waste stream should be excluded from the 100 kg sample.

A statistical basis for this subjective decision is based on the concept of the standard deviation and the normalized "bell curve" of percent composition of waste materials. If the weight of a single item in a sample would cause the percent composition for that material to be greater than three standard deviations from the average percent composition of that material, the item should not be included in the sample. This information is never available in the field, therefore a judgement based on what should be considered "normal" residential waste and what should be included in the sample must be made. A person experienced in waste composition analysis should make this decision.

Large or bulk items are often collected by the municipality on special collection days. These collection days may be weekly, monthly, seasonal (spring/fall), or yearly. For the purposes of determining the per capita generation rates and composition of such materials a yearly monitoring scheme should be set up. This monitoring program could be initiated at the same time as the monitoring program for yard waste since these two waste streams may be linked by collection practices in the municipality.

6.5 Apartment Buildings

During the collection of waste samples, two types of apartment buildings will be encountered that will require special sampling and data collection procedures.

6.5.1 Small Apartment Buildings

In the housing classification of "Mixed Dwellings" the collection crew will often come across small apartment buildings, rooming houses and interconnected dwellings.

Apartment buildings with a small number of units will usually have all the waste set out at the curbside. This waste should be included in the sample, and the number of occupied units in the building recorded.

Larger apartment buildings will often generate enough waste to make up one entire 100 kg sample. Such buildings should be noted during the selection of starting points, and may be selected as sampling locations. The total weight of all refuse set out from the building must be recorded along with the number of occupied dwellings. Any additional waste above the required 100 kg sample size may be returned to the curb to reduce sample sorting time later on.

On occasion waste will not be set out at the curbside, but may be present in a dumpster or storage room. All waste should be removed from the dumpster or storage room and its weight recorded. This activity will require consent of the building superintendent or operator, and such permission should be obtained before the collection begins.

6.5.2 Highrise Apartment Buildings With Dumpsters and Compactors

The housing classification of "Multiple Dwellings" refers to enumeration areas comprised entirely or in part by apartment buildings of 30 or more units. These buildings present several practical problems for the waste study which must be addressed.

1. The ten 100 kg samples should be taken equally from all the dumpsters or compactors, if more than one dumpster is present. This can be achieved by skimming a layer of waste off the top of one dumpster to make up one sample, then moving on to the next dumpster for the next sample. It may be necessary to return to each dumpster more than once to collect all 10 samples.
   Samples of loose waste from broken or compacted bags should be rebagged in 6 mil polyethylene bags.

2. After the ten samples are have been collected the remaining waste must be weighed, and its weight recorded along with the number of occupied dwellings in the building. Weighing of the remaining waste is often best accomplished by contracting a waste hauler to dedicate one truck to pick up the waste from the apartment building, take it directly to a transfer station, and return the weigh scale receipt to the study team.

In the absence of such an arrangement with a private hauler, or where only small amounts of waste remain, the study crew can weigh and record the weight of the waste on the portable scale, and return the excess waste to the dumpster.

6.6 Logistics of Sample Collection

The collection of waste samples and supporting data requires a large degree of co-ordination between the study team, Ministry of the Environment officials, municipal authorities and staff, building owners, waste haulers and others.

6.6.1 Documents and Meetings

Two important documents must be obtained from the Ministry of the Environment, Waste Management Branch. The first authorizes the collection of waste for the Waste Composition Study; the second is a letter to be given to any individual in the municipality who is interested in learning more about the residential study.

The procedure to obtain Ministry approval for solid waste sample collection by municipalities undertaking waste composition studies, is as follows:

A letter requesting Ministry approval for temporary collection of solid waste samples shall be mailed by the interested municipality to:

Mr. Dave Crump
Operations Coordinator
Operations Division
Ministry of the Environment
14th Floor, 135 St. Clair Ave., West
Toronto, Ontario
M4V 1P5

The letter shall include, but not be limited to the following type of information:

- Background and reasons for undertaking the study.
- Study objectives.
- Study approach.

- Contractor's name.
- Collection area.
- Approximative number of samples to be collected.
- Approximative weight of each sample.
- Estimated duration of the project.

A high level of coordination is required between the Study Project Manager, municipal staff and waste haulers to ensure scheduling of refuse collections. Each week, a map of the EA scheduled for inclusion in the refuse study should be delivered to municipal staff and/or the waste haulers.

The study team must be informed of the regular collection day in the study enumeration area, whether there is once or twice weekly collection, the ratio between first and second day set-out rates (e.g. 60/40 spilt) when there is twice weekly collection, and any other potential collection problems such as rescheduling at holiday times.

The municipal waste collection crews should be directed away from the study area for at least three hours to allow the study team to collect samples.

A similar level of coordination is required in order to obtain permission to include small and large apartment buildings in the Study. Usually the details can be arranged through phone conversations with apartment owners and building managers and waste haulers, but occasionally written requests for permission are required.

In North Bay, a press release was issued by the City to inform its residents about the City's participation in the Ontario Waste Composition Study. This may be helpful in facilitating the collection crew's activities.

SECTION 7

STAGE 4 - WASTE SORTING AND ANALYSIS

7.0 STAGE 4 - WASTE SORTING AND ANALYSIS

Stage 4 describes the methods to be used by the study team to analyze the waste samples after they have been collected. These analyses include sorting the waste into its material components and weighing each material, determining moisture content, and optional analyses such as BTU (heating value analyses) and metal content.

7.1 Sorting Location

Samples of waste are returned to a central location where sorting and weighing can take place. The sorting location varied with the municipality being studied and the seasonal weather. In general the sorting location had to be large enough to allow the sorting team to set up a work table and an array of plastic buckets, and should provide some protection from the elements.

In the Town of Fergus, sorting was conducted at the Guelph Landfill Site. No shelter was provided except for a large tarpaulin which was used as a sun-screen during the hot summer months.

In Borough of East York sorting was conducted on the tipping floor of the former Commissioners Street Incinerator. This location provided adequate protection from the wind and cold during the months of November and December. On very cold days the work was moved into a heated work room adjacent to the tipping floor.

In the City of North Bay sorting was carried out in a large (20 ft. by 20 ft.) carnival-type tent. The study took place during the month of February, during which times temperatures were continually well below freezing. The tent was heated with two 15,000 BTU propane heaters.

7.2 Sorting Equipment and Set-up

Sorting of waste samples was conducted on a large wooden table around which all of the sorting team could stand. The table was constructed out of one inch plywood sheets, supported either by the tail-gate of the pick-up truck or on saw horses (see Figure 4).

The sorting team position themselves around the table and set up the array of plastic sorting buckets (30 litre plastic garbage cans) into which the various components of the waste are sorted (see Figure 4).

The sorting buckets are arranged to promote the idea of "handedness". To begin with, a bucket for putrescibles which is placed directly in front of each sorter. This provides the least amount of handling for the largest component by weight, and the most difficult component to handle.

Each sorter then shares a bucket for each of the other components with either the sorter on the right or on the left. For example, the buckets could be arranged so that a sorter is placing all paper categories to the left side and all plastic categories to the right side. Buckets for the larger and heavier objects can be placed behind the sorters, at a further distance but should be shared by two or more sorters. This arrangement of buckets allows the sorters to pick up an item and deposit it in the correct bucket without having to transfer the object from hand to hand, once the idea of " handedness" is established.

Additional equipment required for the sorting procedure includes:

- 150 kg capacity platform scale (noted previously);
- 1.5 kg capacity scale (Accurate model 5000 (electronic, battery operated with digital read-out), Exact Weight Scale Inc., Toronto, Ontario.);
- 40 polyethylene garbage cans (noted above);
- 1 claw hammer
- 1 slotted screw driver;
- 1 electrician's pliers;
- 4 magnets
- paring knives for opening plastic bags
- personal equipment listed Section 7.6.6

7.3 Waste Component Categories

The samples of waste are sorted into the categories shown in Table 7. The categories were listed on data collection sheets which allowed the weight of each component to be recorded opposite of it. Space should also be available on the data sheet for recording of miscellaneous items that do not fit the predetermined categories. The information recorded on the data collection sheet for each sample can then be transferred directly to computer spreadsheets for analysis.

Notes On the Categories

While sorting/classifying the waste samples certain items, such as a glass bottle, are simple to categorize. Some waste materials may be composed of several different materials in layers or otherwise combined which makes identification difficult. Other waste materials, due to their unique physical or chemical structure, will not fall into obvious categories. The degree and level of detail to which the Ontario Waste Composition Study waste material categories have been subdivided reflects an effort to deal with these sorting problems.

In general, if a material could be identified by a unique identifying keyword or phrase in addition to its generic material composition, that descriptor formed the basis for its classification. The generic categories of paper, glass, ferrous metal, non-ferrous metal, plastics and organics each have several subcategories. In addition several unique categories are used such as diapers (disposable), dry cell batteries, kitty litter, and medical waste are used.

TABLE 7: WASTE COMPOSITION DATA COLLECTION SHEET

Town:
Enumeration Area:
Collection Dates:

(1) Paper	(a) Newsprint					
	(b) Fine Paper / CPO / Ledger					
	(c) Magazines / Flyers					
	(d) Waxed / Plastic / Mixed					
	(e) Boxboard					
	(f) Kraft					
	(g) Wallpaper					
	(h) OCC					
	(i) Tissues					
(2) Glass	(a) Beer	(i) refillable				
		(ii) non-refillable				
	(b) Liquor & Wine Containers					
	(c) Food Containers					
	(d) Soft Drink	(i) refillable				
		(ii) non-refillable				
	(e) Other Containers					
	(f) Plate					
	(g) Other					
(3) Ferrous	(a) Soft Drink Containers					
	(b) Food Containers					
	(c) Beer Cans	(i) returnable				
		(ii) non-returnable				
	(d) Aerosol Cans					
	(e) Other					
(4) Non-Ferrous	(a) Beer Cans	(i) returnable				
		(ii) non-returnable				
		(iii) American				
	(b) Soft Drink Containers					
	(c) Other Packaging					
	(d) Aluminum					
	(e) Other					
(5) Plastics	(a) Polyolefins					
	(b) PVC					
	(c) Polystyrene					
	(d) ABS					
	(e) PET					
	(f) Mixed Blend Plastic					
	(g) Coated Plastic					
	(i) Nylon					
	(i) Vinyl					
(6) Organic	(a) Food Waste / Rodent Bedding					
	(b) Yard Waste					
(7) Wood						
(8) Ceramics / Rubble / Fiberglass / Gypsum Board / Asbestos						
(9) Diapers						
(10) Textiles/Leather/Rubber						
(11) Household Hazardous Wastes	(a) Paints / Solvents					
	(b) Waste Oils					
	(c) Pesticides/Herbicides					
(12) Dry Cell Batteries						
(13) Kitty Litter						
(14) Medical wastes						
(15) Miscellaneous						
(16) BLUE BOX ITEMS	(a) Newsprint					
	(b) Liquor / Wine Bottles					
	(c) Food Jars / Other Bottles					
	(d) Food Cans	(i) ferrous				
		(ii) non-ferrous				
	(e) Beer Cans	(i) ferrous				
		(ii) non-ferrous				
		(iii) American				
	(f) Pop Cans	(i) ferrous				
		(ii) non-ferrous				
	(g) PET Bottles					
	(h) Plastic Jugs					
	(i) OCC					

When an item was found to be composed of several materials, the most predominant material by weight was used as the basis for classification. For example a paper container with a thin coat of plastic would be classified as waxed/plastic/mixed paper (item **1d**). Similarly a plastic bag with a thin aluminum foil liner (potato chip bags) would be classified as coated plastic (item **5g**).

Dr. Fred Edgecombe, Executive Director, EPIC (Environment & Plastics Institute of Canada) recommended that all polyethylene and polypropylene containers and film plastics be grouped together as "polyolefins" (item **5a**), rather than trying to distinguish between polyethylene of different densities and crystal linearity. A small amount of SARAN wrap (polyvinylidene chloride) would also have been included in this category.

The PVC category (item **5b**) was restricted to rigid containers; the vinyl category was reserved for other materials such as scraps of vinyl siding.

A simple "smoke and drip" test, provided by Dr. Edgecombe, was used to assist in determining the category for a particular plastic item. The test is included as Appendix D of Volume I, but it should **not** be viewed as a definitive qualitative method when used by itself and the test is not presented in this report. The sorting team should receive training from a person knowledgable in distinguishing plastic types during their general job training.

Mixed blended plastics (item **5f**) were used to classify plastic packaging around meat products. Coated plastics (item **5g**) were used to classify packaging in which the plastic portion was judged to be the greatest percentage by weight, e.g., potato chip bags. The "Tetrapak" boxes were categorized as mostly paper (boxboard) and included in item **1d**.

Rodent bedding (item **6a**) was routinely encountered in small quantities of urine-soaked cedar shavings and faecal pellets. The material was included in the food waste category because of the putrescible nature of both of the components. Likewise, individual "packages" of canine excreta--presumably contributed by citizens obeying the "poop-and-scoop" statutes--were included in this category. Kitty litter (item **13**) was more frequently encountered and because of the inorganic nature of the granular product was given a single, separate category.

Sanitary napkins were included in the paper subcategory of tissues (item **1i**).

Medical wastes (item **14**) included medicines, insulin bottles and associated used syringes (needles protected and unprotected) and syringes without accompanying evidence of medicinal application.

Aerosol cans were collectively weighed and included in the ferrous section as item **3d**. At the time, we felt that one category for ferrous/non-ferrous pressurized containers would be adequate owing to the small number of non-ferrous aerosol containers. An additional category for non-ferrous aerosol containers may be incorporated into the sorting routine.

7.4 Weighing Sorted Waste - Use of Tared Buckets and Electronic Scales

After sorting, each material can be weighed in its bucket. The electronic platform scale (150 kg capacity) should be "tared" with an empty bucket so that the scale reads only the weight of the material in the bucket. Scale tare should be checked frequently to ensure that the scale is operating properly. One person can be designated as the data recorder, while the remainder of the crew load the scale, and empty the buckets that have been weighed.

Often there will be several small items that are too small to be weighed on the 150 kg capacity platform scale. These small items should be weighed separately on a smaller (1.5 kg capacity) scale.

7.5 Use of Standard Data Sheets - Recording Weights

Standardized data recording sheets such as shown in Table 7 should be used to record all weights. The sample being analyzed, the enumeration area from which it was taken, and the date of sorting should be clearly indicated on each sheet. If one person acts as the designated record keeper, fewer mistakes and omissions are likely to occur.

7.6 Personnel Training - Safety

During the sorting exercise several safety precautions should be taken. Safety includes proper handling of the waste samples, protective clothing, hygiene, and immunization. With limiting the generality of safety requirements, several comments regarding safety are made.

7.6.1 Waste Handling

When handling waste the collection crew and sorters must be aware of sharp and pointed objects, corrosive and caustics chemicals, hazardous and poisonous chemicals, and potential disease carrying objects such as dead animals, insects, medical waste and so on. Careful and watchful work will allow workers to spot these items and avoid coming into contact with them.

7.6.2. Protective Clothing, Hygiene, and Immunization

All members of the collection and sorting crew should dress appropriately for the work conditions, and wear the proper protective equipment. Personal equipment includes:

- heavy duty, water proof (PVC coated) gloves;
- work clothes (pants and long sleeve shirts) or coveralls; rubber apron, hat;
- steel toed work boots;
- eye protection;
- tetanus/polio vaccination (optional: diphtheria, Hepatitis A and Hepatitis B);

- traffic safety vest
- particle masks, worn by crew members concerned with dust and the possibility of disease transmission;
- anti-bacterial soap, used to clean gloves hands and face before meal breaks and at the end of the day.

Efforts should be made to maintain personal hygiene during sorting, as this will reduce any possible disease transmission. Contact with eyes, ears and mouth should be avoided until hands and face have been thoroughly washed with anti-bacterial soap.

7.7 Moisture Content Analysis - Optional

Analysis of moisture content is optional for the purposes of this study, but is useful when comparing percent composition and per capita generation rates between enumerations, during different seasons, and between different years. The moisture content of the waste allows you to identify samples that may be very wet or very dry, and hence have a greater or lesser weight than expected. Samples of waste should be analyzed as soon after collection and sorting to reduce the amount of moisture transfer taking place.

After the waste sample has been sorted into the designated categories and weighed, samples of plastics, paper, food waste, disposable diapers, and textiles are placed in large polyethylene bags, folded and stapled shut, and transported to a drying laboratory. The contents of the bags are weighed, and placed in a waste drying oven at 95 C for 48 hours. The samples are reweighed after the 48 hour period to determine the weight loss due to evaporation of moisture.

7.8 Other Optional Analyses - BTU, Leachable Metals

Other analyses were undertaken during the Ontario Waste Composition Study which may include determining the heating value of the waste by assessing its BTU value, and determining the leachable metal content of various waste components. Results of the BTU analysis and heavy metal content of vacuum cleaner bag dust are presented in Volume I.

7.9 Yard Waste Data Collection

During collection of waste samples, yard waste (leaves, grass clippings, tree trimmings) should be omitted from the 100+ kg sample. When yard waste is encountered at the curb its weight should be recorded, and the yard waste returned to the curb. The total weight of yard waste found in the sorted waste and the weight of yard waste weighed and returned to the curb during sample collection is recorded on the data collection sheets, but the weight of yard waste is not included in the calculation of the percent composition of waste.

SECTION 8

STAGE 5 - DATA ANALYSIS AND MANIPULATION

8.0 STAGE 5 - DATA ANALYSIS AND MANIPULATION

Data collected in Stage 3 and Stage 4 must be summarized and analyzed. This section describes the calculations necessary to determine the per capita generation rate (kg/capita/day), and the percent composition of residential waste.

8.1 Using a Computerized Spreadsheet to Summarize Data

For the Ontario Waste Composition Study, Gore & Storrie Limited created a computerized spreadsheet to calculate and summarize percent composition for each 100 kg sample and each enumeration area. Similar data spreadsheets can be created for each community.

The Gore & Storrie spreadsheets are designed such that the data entry operator enters the weight of each waste component recorded during the sorting procedure, and the computer calculates:

- percent composition of each waste component in the 100 kg sample;
- average percent composition for the enumeration area;
- average weight of each waste component in the 100 kg sample;
- standard deviation of the average percent composition and average weight of each waste component;
- standard error of the average percent composition and average weight of each waste component.

Computerized spreadsheets can be printed out in report format if needed.

8.1.1 Percent Composition of Waste

Percent composition is calculated by dividing the weight of each sorted material (MATERIAL WEIGHT) by the sum of the material weights (TOTAL WEIGHT), and expressing the result as a percent.

MATERIAL WEIGHT ÷ TOTAL WEIGHT x 100% = PERCENT COMPOSITION

The percent composition of each component of the waste stream is only relevant if an estimate of the per capita generation rate (kg/capita/day) of waste is available. The per capita generation rate of all wastes (calculation of which is described in Section 8.2 below) combined with the percent composition of waste allows an estimation to be made of the tonnage of each component generated by the municipality. Reporting the percent composition of the waste stream, without reporting a total tonnage figure or per capita generation rate for the municipality is meaningless.

8.2 Calculation of Per Capita Waste Generation Rate

Calculation of per capita generation of residential waste requires the following:
Per capita generation rate of waste is calculated based on the number of dwellings waste is collected from, the average number of persons per dwelling, the weight of waste collected, and the number of days over which the waste was generated.

Refer to Table 8 for an example of per capita generation rate calculation.

TABLE 8: SAMPLE CALCULATION OF THE PER CAPITA GENERATION RATE IN AN EA. DATA FROM THE FICTIONAL TOWN OF ANYTOWN, EA # 107

Town: Anytown
EA: 107 / High Income; Primarily Single Detached Dwellings
Pop: 1020
Dwellings: 360
PPD: 2.83

Sample Number	Dwellings with Refuse	Dwellings with Blue Boxes	Sampled Refuse Weight (kg)	Sampled Blue Box Weight (kg)	Daily Weight /Dwelling (kg/day)	Waste /person /day (kg)	S.E.
31	8	5	115.80	31.11	2.51	0.887	
32	11	5	96.39	26.38	1.63	0.576	
33	6	3	123.52	24.30	3.52	1.244	
34	8	7	96.82	39.50	2.13	0.753	
35	12	8	103.06	45.80	1.64	0.580	
36	9	7	113.69	37.20	2.18	0.770	
37	2	2	42.12	40.36	4.45	1.572	
38	5	5	89.83	15.58	2.79	0.986	
39	7	4	122.68	12.65	2.73	0.965	
40	11	6	141.71	22.39	2.11	0.746	
Sample Ave.	7.9	5.2	104.56	29.53	2.57	0.908	0.097

8.2.1 Municipalities with Blue Box Recycling

In communities with Blue Box recycling programs calculation of the per capita generation rate of waste requires determining the generation rate of regular waste, and the generation rate of Blue Box materials. This presents a minor problem in that the households do not usually set their Blue Box out every week. The Blue Box is normally only set out when it is full. The time for the blue box to fill up may be one, two or more weeks, therefore some estimate of the put-out rate or timing set out of blue boxes must be made.

It is erroneous to assume that Blue Boxes are set out each week. Making this assumption will cause the per capita generation rate of all wastes to be too high, and will give false information regarding the effectiveness or capture rate of the Blue Box program. Accurate estimates of the typical put-out rate can only be made by carefully monitoring the Blue Box program. The persons riding the collection trucks may have valuable insight into the put-out frequency in the municipality or even the enumeration area being studied.

Calculation of generation rate proceeds as follows:

- Determine the total sample weight (WASTE WEIGHT) of waste collected (for each 100+ kg sample). These data are recorded in the trip note book.
- Determine the number of dwellings (DWELLINGS) waste was collected from to achieve each 100 kg sample. These data are recorded in the trip notebook.
- Determine the total weight of Blue Box (BLUE BOX WEIGHT) material collected (for each 100+ kg sample).
- Determine the number of dwellings Blue Boxes (BLUE BOXES) recyclable material was collected from. These data are recorded in the trip notebook.
- Determine, by consultation with municipal officials, the typical put-out rate of Blue Boxes (PUT-OUT RATE). For example, Blue Boxes may be put out every two weeks by the residents, as opposed to weekly. Therefore the PUT-OUT RATE is once every 14 days
- Determine the average number of persons per dwelling (PPD) from the Census information
- The daily weight of waste generated by each dwelling is calculated:

(WEIGHT (kg) ÷ DWELLINGS ÷ 7 (days)) +
(BLUE BOX WEIGHT (kg) ÷ BLUE BOXES ÷ PUT-OUT RATE (days)) =
DAILY WEIGHT/DWELLING (kg/dwelling/day)

- The per capita generation rate is calculated:

  DAILY WEIGHT/DWELLING ÷ PPD = WASTE/PERSON/DAY (kg/capita/day)

8.2.1.1 Anytown: Calculation of Per Capita Generation Rate of Waste

In Anytown, enumeration area 107 was studied as part of the waste composition study. The data and calculations for the average per capita generation rate in enumeration area 107 are shown in Table 8.

In Anytown it was determined that Blue Boxes were set out by the residents every two weeks, for a put-out rate of 14 days (PUT-OUT RATE = 14 days). Ten samples of regular household waste and Blue Box Materials were collected in enumeration area 107.

For sample number 31, the calculation of the per capita generation rate is as follows (see Table 8). Note that regular waste was collected from 8 dwellings, while Blue Box material was collected from only 5 dwellings.

- The daily weight of waste generated by each dwelling is calculated:

  (WEIGHT (kg) ÷ DWELLINGS ÷ 7 (days)) +
  (BLUE BOX WEIGHT (kg) ÷ BLUE BOXES ÷ PUT-OUT RATE (days)) =
  DAILY WEIGHT/DWELLING (kg/dwelling/day)

  (115.80 kg ÷ 8 DWELLINGS ÷ 7 days) +
  (31.11 kg ÷ 5 DWELLINGS ÷ 14 days) = 2.51 kg/dwelling/day

- The per capita generation rate is calculated:

  DAILY WEIGHT/DWELLING ÷ PPD = WASTE/PERSON/DAY (kg/capita/day)
  2.51 kg/dwelling/day ÷ 2.93 persons/dwelling = 0.857 kg/capita/day

8.2.2 Municipalities With No Blue Box Recycling

In the absence of Blue Box recycling the calculation of the per capita generation rate is much more simple. The estimation involved in determining how many days or weeks blue box materials are accumulated over before being set out for collection is not required.

Calculation of the per capita generation rate proceeds as follows.

- Determine the total sample weight (WASTE WEIGHT) of waste collected (for each 100+ kg sample). These data are recorded in the trip note book.
- Determine the number of dwellings (DWELLINGS) waste was collected from to achieve each 100 kg sample. These data are recorded in the trip notebook.
- Determine the average number of persons per dwelling (PPD) from the Census information
- The daily weight of waste generated by each dwelling is calculated:

  (WEIGHT (kg) ÷ DWELLINGS ÷ 7 (days)) =
  DAILY WEIGHT/DWELLING (kg/dwelling/day)
- The per capita generation rate is calculated:

  DAILY WEIGHT/DWELLING ÷ PPD = WASTE/PERSON/DAY (kg/capita/day)

8.2.3 Estimation of a Weighted Generation Rate for the Municipality

The average per capita generation rate for the enumeration area is calculated by taking the mean of the per capita generation rates of each of the 100+ kg samples taken. The average per capita generation rate for each enumeration area studied is then used to estimate the overall weighted generation rate for the municipality.

In the municipality there may be one or more enumeration areas assigned to each income/housing classification type. The number of enumeration areas in each cell of the income/housing matrix, expressed as a percentage of the total number of enumeration areas in the municipality, acts as the weighting factor for the calculation of the weighted per capita generation rate.

The calculation is as follows:

- Determine the average per capita generation rate (AVERAGE WASTE/PERSON/DAY) (kg/capita/day) for the each income/housing type classification from the enumeration areas studied.
- Determine the number of enumeration areas in each income/housing classification matrix cell, expressed as a percentage (PERCENT) of the total number of enumeration areas in the municipality.
- AVERAGE WASTE/PERSON/DAY x PERCENT = WEIGHTED PER CAPITA GENERATION RATE

8.2.3.1 Anytown: Calculation of the Weighted Per Capita Generation Rate

Table 9 shows the calculation of the weighted per capita generation rate for the entire town of Anytown. Each of the cells of the income/housing classification matrix has been assigned a "weight" based on the number of enumeration area falling into that cell.

The calculation of the weighted per capita generation rate is as follows.

WEIGHTED PER CAPITA GENERATION RATE (kg/cap/day)

```
Weighted Sum of          |    waste     |       |     EAs in the cell as    |
Cells A1-C3 in      =    | generation   |   x   |percentage of total number|
income/housing           |  rate in a   |       |of EAs in the municipality|
    matrix               | matrix cell  |       |   (for Study purposes)    |
```

8.3 Waste Component Generation Rate

The percent composition of waste is only meaningful given an estimate of the per capita generation rate of waste for the municipality. To determine how many kilograms or tonnes of a certain material are generated (GENERATED) in an enumeration area, or the municipality, over a set time period the percent composition

TABLE 9: RESIDENTIAL WASTE GENERATION DATA INCORPORATED INTO THE INCOME/HOUSING MATRIX TO ESTIMATE THE WEIGHTED PER CAPITA GENERATION RATE (KG/CAPITA/DAY) FOR THE FICTIONAL TOWN OF ANYTOWN.

	(1) Primarily Single Detached	(2) Mixed Dwellings	(3) Primarily Multiple Dwellings
(A) High Income	0.908 (13.3%)	0 (0%)	0.867 (6.7%)
(B) Medium Income	0.879 (26.7%)	0.811 (20.0%)	0.622 (13.3%)
(C) Low Income	0 (0%)	0.798 (13.3%)	0.783 (6.7%)

Weighted per capita generation rate (kg/capita/day) = 0.817

(PERCENT) of that material is multiplied by the per capita generation rate (GENERATION RATE) estimated for the enumeration area, or for the municipality.

- PERCENT (%) x GENERATION RATE = GENERATED
  (kg/capita/day) (kg/capita/day)

SECTION 9

ANALYSIS OF WASTE FROM SCHOOLS & OTHER INSTITUTIONS

9.0 ANALYSIS OF WASTE FROM SCHOOLS & OTHER INSTITUTIONS

9.1 Per Capita Waste Generation

Determination of the per capita generation rate is conducted in the same way as it is for large multi-unit apartment buildings. The total weight of waste generation for the week is determined by weighing all the waste set out for collection. This weighing procedure may often be facilitated by contracting the normal waste hauler to make a dedicated pick of the waste (picking up no other waste in an empty truck), and returning the weigh scale information from the landfill or transfer station.

The total number of school students or residents in the institution is determined by contacting the institution. The "per capita" generation rate is then calculated based on the total weight of refuse and the total number of persons. In the case of schools, care should be made to determine the number of days people are at the institution, such as only 5 days per week for public and secondary schools.

9.2 Percent Waste Composition

Waste composition from schools and institutions can be determined by taking 100 kg samples and sorting the waste according to the composition categories used for residential waste. As with residential waste, ten samples (nine as a minimum) are required to obtain statistically valid results.

SECTION 10

RECOMMENDATIONS FOR FURTHER REFINEMENT

10.0 RECOMMENDATIONS FOR FURTHER REFINEMENT

Municipalities conducting a waste composition study might consider the following recommendations when designing the sampling protocol and implementing the study methodology.

1) For sampling and sorting convenience, municipalities may choose to conduct the waste composition studies in late spring or mid-fall when refuse odours are less intense and maggots are less frequently encountered. According to Vesling & Rimer (ref. 47), the average residential waste composition does not vary by more than +/- 10% over three quarters of the year. Therefore, aesthetics of the working conditions can be taken into account without risk to obtaining skewed data. The inclusion of yard waste in overall residential waste composition percent profiles should be avoided so that baseline composition percentages are not misrepresented.

2) Municipalities may choose to set up independent collection systems to study the seasonal generation of yard waste and leaves. This would require a coordinated effort between garbage collection personnel, private horticultural firms and other agencies generating and collecting these waste streams.

3) In order to avoid the sampling problems that we encountered with the large apartment buildings in East York, where apparent sampling biases were difficult to avoid, arrangements could be made, for example, with 30 units within the building to participate in a refuse study. This would give a more accurate appraisal of the waste composition in these large apartment buildings. As a check, the method described herein for obtaining the per capita generation rate for the entire building could then be compared with the per capita generation rate for the 30 units.

4) Municipalities in Ontario should follow the waste composition procedure in conducting their own waste composition analysis, for reasons of consistent data generation using a cost effective approach. Periodically, municipalities should conduct additional waste composition studies to monitor trends in residential waste management and the effectiveness of waste management programs.

ACKNOWLEDGEMENTS

ACKNOWLEDGEMENTS

There were many people who contributed to this research project for this manual and they are acknowledged, hopefully without omission.

Town of Fergus:

The Study crew of Bruno D'Addairo, Cila Dadd, Jasmine Essue, Don Tooley and Andrea O'Malley were committed to the task of breaking new ground as they Study unfolded, working the bugs out of the Study methods and labouring under environmental conditions and logistical distances that were trying. They performed admirably.

Mr. George Woods, Clerk-Treasurer, Town of Fergus, and Mr. Don Taylor (Wellington Recycling Group) gave their support to our study in the Town of Fergus. Mr. Adolph Plein (Plein Disposal) and Mr. Peter Armer (McLellan Disposal) were patient and went out of their way to accommodate the Study team's presence in the Town of Fergus. Their cooperation was greatly appreciated.

The staff in the Engineering Department, City of Guelph, particularly, Messrs. Dan Hoornweg and John Bull, smoothly arranged for the landfill site to be our base of operations. The staff at the landfill site were ready with assistance and witty rejoinders, making the task a bit lighter.

Mr. Robert Ferguson, Commissioner of Works, Metro Toronto, gave permission to use the laboratory in the former Ontario Centre for Resource Recovery (OCRR) for the moisture analyses. Mr. Brad Guglietti, Waste Management Branch, MOE, arranged for the loan of a Sartorious balance for this work.

Borough of East York:

The transition of the year from fall to winter saw three new faces; the Study team was: Jasmine Essue (from Fergus), Rob Flindall, Gord McLaren and Cria Pettingill.

They were steadfast and dedicated to fine tuning the procedures that were initiated by the Fergus crew.

The friendly cooperation of the East York Works Department, in particular: Messrs. Paul Cockburn, Jeff Walker, Elliot Hill, Al Karns and Ms. Kathy Killinger, facilitated the curbside collection of residential and school wastes.

Mr. Robert Ferguson, Commissioner of Works, Metro Toronto, gave us permission to sort the East York refuse on the tipping floor of the Commissioners Street incinerator and to continue using the OCRR for the moisture analyses.

A & M Disposal and Industrial Disposal provided important refuse collection services in this phase of the Study.

City of North Bay:

Rob Flindall, Gord McLaren and Dean Wilde (City employee) braved the elements to continue the refuse collecting and sorting in this last phase of the residential Study.

Friendly cooperation was demonstrated by the city of North Bay Engineering Department, in particular, Mr. John Simmonds. The City provided vehicles, the sorting tent and the propane heaters.

In addition to those noted above for the three municipalities, we gratefully acknowledge support and cooperation provided by Messrs. Neal Ahlberg, Brendan Killackey and Dan Ionescu, Waste Management Branch, Ministry of the Environment.

The Gore & Storrie team consisted of: Dick Buggeln, Jeff Flewelling, Leslie MacMillan, Rob Flindall, Peter Kurtz, Barbara St. Hill, David Fox and Brock Harrington.

The team from Decima Research was Messrs. Ian McKinnon, Russ Wilton, and Raj Matuk.

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GLOSSARY

GLOSSARY OF TERMS

ABS	acryl butyl styrene; a dense plastic found in computer housings, telephone casings, pipe.
accuracy	in a statistical sense, the term gives an indication of the closeness of the results, estimates, etc. to the "true" value.
BTU	British Thermal Unit; the amount of heat required to raise the temperature of 1 pound of water 1 Fahrenheit degree
capture rate	The percentage of blue material diverted from landfill compared to the total quantity available for recycling;
commercial wastes	discarded materials generated by commercial businesses as a result of normal activities in the workplace;
ferrous	a metal object containing elemental iron, giving a `positive' or attractive response to a magnet;
mean	the mean or arithmetic mean of a set of values is the sum of the values divided by their number; average;
MSW	municipal solid waste, usually defined as the sum of residential and commercial solid wastes, and excluding industrial wastes;
non-ferrous	a metal object which does not give a `positive' or attractive response to a magnet, e.g., brass, lead, aluminum, etc.
OCC	old corrugated containers; variously called, old corrugated cardboard;

PET	polyethylene terephthalate; the plastic used to manufacture the common 2 litre pop bottles;
polyolefin	in the sense used here, a grouping of chemically related plastics whose chemical building blocks are either ethylene or propylene;
precision	in a statistical sense, the term gives an indication of the repeatability of a series of observations, estimates, etc. The Standard Error is one kind of estimate of the precision or repeatability or "tightness" of the grouping of the observations (= data);
putrescible	a material which is biodegradable; usually a term reserved for animal or vegetable matter;
PVC	polyvinyl chloride; a plastic containing chlorine; well known as siding, plastic window sashes and frames, pipe and a few rigid containers;
Random Number Table	These tables (which are found in many statistical textbooks) consist of blocks of numbers that meet certain properties of "randomness", including that numbers in the range 0 to 9 are equally likely to occur; and that the numbers are not serially ordered in any way. Starting at any point on the Table, the user moves systematically through the Table taking the required number of digits;
residential waste	discarded materials generated by individuals in the course of their daily activities at their place of residence; in this case, exclusive of yard wastes and leaves;
Standard Deviation	a measure of the variation or difference of sample measurements from the mean of all measurements taken;

Standard Error	a measure of how much sample means can be expected to fluctuate (±) from the true mean due to chance;
tare weight	the weight of an empty container;

PART B

COMMERCIAL WASTE COMPOSITION STUDY

TABLE OF CONTENTS--PART B

Page No.

INFORMATION FOR THE READER (i)

TABLE OF CONTENTS (ii)

LIST OF TABLES (iv)

LIST OF FIGURES (v)

EXECUTIVE SUMMARY (vi)

1.0 INTRODUCTION & LITERATURE REVIEW 1-1
  1.1 Introduction 1-1
  1.2 Literature Review 1-4

2.0 METHODOLOGY 2-1

3.0 WASTE STUDY PARAMETERS AND CONSIDERATIONS 3-1
  3.1 Required Waste Generation Rate and Waste Composition 3-1
    3.1.1 Waste Generation Rate 3-1
    3.1.2 Waste Composition 3-1
  3.2 Basis for Defining Commercial Waste Generation 3-2

4.0 MANPOWER, EQUIPMENT AND COST 4-1
  4.1 Personnel 4-1
  4.2 Equipment Used in the Waste Study 4-2
    4.2.1 Seasonal Effects on Equipment Requirements - Shelter and Clothing 4-3
  4.3 Cost of Conducting a Typical Commercial Waste Study 4-4
    4.3.1 Estimated Personnel Time and Disbursement/ Equipment Requirements 4-5

5.0 STAGE 1 - PROJECT INITIATION AND SELECTION OF SIC MAJOR STUDY GROUPS 5-1
  5.1 Obtaining Census Canada Information 5-1
    5.1.1 Defining Commercial Activity 5-1
    5.1.2 Commercial Employment in the Regional Municipality of Waterloo 5-2
    5.1.3 Extrapolation of Sample Data to a Municipality 5-4
  5.2 Regional Municipality of Waterloo Planning Information 5-6
  5.3 Knowing Your Community - Current Waste Management Practices 5-6
      5.3.1 Waste Composition Variability 5-6
      5.3.2 Bulk Item and Special Collection Days 5-8

Table of Contents cont'd...

Page No.

6.0 STAGE 2 - SELECTION OF BUSINESSES 6-1
  6.1 Size and Number of Samples Required 6-1
    6.1.1 Size of Samples Required 6-1
    6.1.2 Number of Samples Required 6-1
  6.2 Contacting Businesses 6-2

7.0 STAGE 3 - COLLECTION OF WASTE SAMPLES 7-1
  7.1 Scheduling Waste Collection 7-1
  7.2 Special Documentation 7-1
  7.3 Waste Collection Methods for Waste Quantities and Composition 7-2
  7.4 Waste Methods for Waste Quantities Only 7-3
  7.5 Information to be Obtained at the Time of Sample Collection 7-4
  7.6 Data Obtained for Per Employee Waste Generation Rates 7-5

8.0 STAGE 4 - WASTE SORTING 8-1
  8.1 Equipment Set-Up and Sorting Commencement 8-1
  8.2 Sample Sorting and Data Management 8-1

9.0 STAGE 5 - DATA ANALYSIS AND REPORT WRITING 9-1
  9.1 Estimates of Average Per Employee Waste Generation Rates 9-1
    9.1.1 Estimates From Average Waste Weight Per Employee Data 9-2
  9.2 Estimation of Waste Generation by Commercial Sector in the Entire Municipality 9-2
  9.3 Sources of Potential Error in Employee Waste Generation Estimates 9-3
  9.4 Per Employee Waste Generation Rates 9-4
  9.5 Estimation of Commercial Waste Generation in the Regional Municipality of Waterloo 9-5

10.0 EVALUATION OF METHOD 10-1
  10.1 Timing of the Waterloo Study 10-1
  10.2 Graphical Presentation of Waste Generation Versus Employment Potential Method to Evaluate Company Waste Management Performance? 10-1
  10.3 Usefulness of Landfill Data in Estimating Commercial Refuse Quantity 10-2
  10-4 Verification of the Employee Waste Generation Estimates 10-3
  10-5 "Light Industry" 10-3

11.0 RECOMMENDATIONS FOR FURTHER REFINEMENT 11-1

ACKNOWLEDGEMENTS

REFERENCES

APPENDIX A

GLOSSARY OF TERMS

LIST OF TABLES--PART B

		Following Page No.
TABLE 1	COMPARISON OF WASTE COMPOSITION INFORMATION FOR THE COMMERCIAL SECTOR PUBLISHED DATA (PERCENT OF TOTAL)	1-5
TABLE 2	WASTE COMPOSITION DATA FIELD SHEET	3-1
TABLE 3	LIST OF SIC DIVISIONS	5-2
TABLE 4	LIST OF THE 13 SIC CODE MAJOR STUDY GROUPS	5-2
TABLE 5	WASTE COMPOSITION DATA FIELD SHEET	8-1
TABLE 6	ACCURACY IN WASTE ESTIMATION - SOURCE OF POTENTIAL ERROR	9-3
TABLE 7	SIC GROUP 631, WASTE GENERATION DATA (KG/EMPLOYEE/DAY) FOR THE AUTOMOBILE DEALERS	9-4
TABLE 8	AN EXAMPLE OF ESTIMATES OF COMMERCIAL WASTE GENERATION IN A MUNICIPALITY	9-5
TABLE 9	COMPARISON OF PER EMPLOYEE WASTE GENERATION RATES: RHYNER & GREEN AND PRESENT STUDY	10-3

LIST OF FIGURES--PART B

		Following Page No.
FIGURE 1	STAGES OF COMMERCIAL WASTE COMPOSITION STUDY WATERLOO	2-1
FIGURE 2	WEIGHING COMMERCIAL BIN REFUSE IN A CRIB MOUNTED ON AN ELECTRONIC DIGITAL SCALE	7-3
FIGURE 3	REMOVING REFUSE FROM BIN	7-3
FIGURE 4	SORTING AT LANDFILL SITE	7-3
FIGURE 5	SIC GROUP 631, GRAPH OF WASTE GENERATION DATA FOR THE AUTOMOBILE DEALERS	9-4

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The Ministry of the Environment contracted Gore & Storrie Limited, in association with Decima Research Limited, to develop and test methodologies that would assist waste management planners and municipalities in deriving reasonable estimates of material composition and generation rate of wastes from residential and commercial sources. The two-fold purpose of the Commercial Waste Composition Study was to:

1. develop a simple, cost effective and reliable method for determining the composition and per employee generation rate of waste from commercial sources in Ontario (the study concentrated on that portion of the commercial waste stream that can be closely related to residential waste; that is, both waste streams stem from the same processes of consumption); and

2. apply the method and obtain current information on the characteristics of commercial waste streams.

A review of relevant literature and consultation with experts in the fields of employment, commercial structure, demographics and waste management indicated that commercial waste generation is related to the number of employees at a particular commercial establishment.

Commercial activity in Canada is organized by the Standard Industrial Classification (SIC) established by Statistics Canada. This classification was used as the basis for reporting waste composition and per employee generation rate data. Before the field study began, the commercial business SIC codes were reviewed with respect to retail/service activities to determine whether certain sectors could be grouped together.

The Census of Canada (1986) gathered information about occupation, type of employment and place of work from a twenty percent (20%) sample of households. These data provide information about the number of employees in 36 different commercial sectors within each of the urban census areas in Ontario. The development of methodology for the commercial waste sector was tested in the Regional Municipality of Waterloo (Region/Waterloo), as presented in Volume II and made use of this kind of information. The field study was undertaken in the Region between May 15 and August 31, 1990.

A representative sample of businesses from the SIC groupings were identified and approached by the study team to gain permission to include them in the study. Data were then gathered on the composition of the waste stream from each SIC grouping, and an estimate of the average generation rate of total waste per employee was made for each of the SIC groupings.

The relationship between waste generation and employment was completed by regression analysis when the characteristics of the data set, (eg. sample size) permitted. In other cases an average of the waste generation data is reported where regression analysis was deemed inappropriate.

Estimated average per employee waste generation rates for each commercial activity were multiplied by the total Regional employment in the activity to obtain estimates of the waste generation for the activity throughout the entire Region.

Part B of Volume III, presented herein, describes the methodology utilized in the aforementioned study for measuring waste generation and waste composition for commercial activities.

Canada Census refers to commercial businesses as industries but does not distinguish between "light" and "heavy" industries. Compared to commercial establishments, light manufacturing industries and wholesale divisions are fewer in number and far more diverse in size and specialization. Some municipalities have many factories, others have virtually none. Waste generated by such activities must be studied on site-by-site basis. Nevertheless, the methodology described herein offers a "starting point" for persons studying the waste generated by light industries and wholesale activities.

The methods developed and used in this study were found to be cost effective and capable of being used by municipal staff. Recommendations are presented in this volume to further refine the methods used.

Ontario municipalities are encouraged to use the methods demonstrated in this manual to satisfy municipal needs, to generate further data on a consistent province-wide basis and to assist in assessing the effectiveness of new waste management programs and identifying trends in waste composition and generation rates.

The study of waste composition from commercial activities is more complex than that from residential sources (refer to Volume I of the Ontario Waste Composition Study and Part A of the procedures manual). First, very little information was available regarding commercial waste composition (none for Canada in recent years) and therefore the research team had little a priori knowledge of expected values or variance to guide the design of an efficient sampling framework. Second, commercial activities are characterized by very high variance relative to the residential sector. Third, it is difficult to identify the population base for a sample of commercial activities. Therefore, the qualitative and quantitative data presented herein should be cautiously regarded as best estimates only.

Recommendations for Further Refinement

The methods employed in the commercial portion of the Ontario Waste Composition Study have been demonstrated on a selection of commercial businesses in the Regional Municipality of Waterloo. Within the commercial sectors in the Region there is a relatively high awareness of waste diversion options that will reduce waste disposal costs and encourage recycling. Therefore, the qualitative and quantitative data presented herein is cautiously regarded as a best estimate for the Region of Waterloo and may be different in other municipalities under constantly changing circumstances.

This report has developed a procedure for estimating the amount of waste generated by commercial activities within Ontario urban areas and began with the process of integrating the complex data inputs required.

The study has employed a two-stage estimation process: (1) the development of ratios of waste generation per employee; and (2) the estimation of commercial employment composition for the municipality as a whole. Each step poses different problems. The following recommendations are submitted:

1. The waste generation and composition data base will require many more samples in order to cover the full range of commercial activities. No one study will have the resources to undertake a complete evaluation; the research results must be accumulated over many studies and evaluated over time. Fortunately, there is no inherent reason that a business in any part of the province cannot be used to estimate waste generated elsewhere--unless local waste management policies differ significantly.

   This means that each study should use the same SIC identification to code commercial activity and the same methodology for measuring waste output and composition. A central agency (e.g., the Ministry of Environment) may have to take the responsibility for organizing and evaluating the data.

2. It will also be necessary to monitor any changes over time in waste generation that may reflect innovations in policy, technology or corporate behaviour. The date of each sample must be retained and/or it may be necessary to identify sample locations that can be restudied over time in order to minimize sampling error.

3. To better understand the effect of recycling behaviour on the data gathered, it is recommended that employees/management of participating firms be asked to describe the nature and extent of any source separation recycling activities.

4. The immediate priorities for sampling can be identified from the results of this study. Those commercial activities that employ large numbers of people must be further investigated in order to improve sample size and reveal any significant variation within the SIC groups; this includes the diverse set of office and financial activities. Conversely, those activities with a high rate of waste generation per employee, such as food stores and restaurants, must be sampled repeatedly because of their importance to the overall waste generation. Those sectors where the observed sample variance (standard

deviation) is high require larger samples to improve overall accuracy, possibly by isolating subgroups within the SIC. Activities that generate policy-relevant waste materials should be given special attention.

5. The future development of employment estimates requires two divergent approaches. First, substantial savings may result from a centralized, standardized analysis of employment that applies the same set of data, techniques and projections to all urban areas--much as the Ontario Statistical Centre has developed a common set of population forecasts.

   At the same time, municipalities have better information about local peculiarities and exceptions to the employment structure. These special cases, e.g., community colleges, tourist attractions, shopping concentrations, as well as manufacturing activities, may require special attention by a local agency.

6. During the course of the Waterloo Study, insights were noted regarding the effectiveness of waste management practices of some firms. For example, for automotive repair businesses, it appears that employee's tend to use the general refuse bin for discarding metal waste materials, despite the fact that a scrap metal bin has been made available.

   Such insights, when communicated to the management of the firm provide an immediate opportunity to help that firm improve the efficiency of their recycling efforts.

   There is also an indication that differences exist in per employee waste generation rates in small grocery stores and in larger supermarkets.

   The demonstrated method for estimating the rate of employee waste generation has the potential to be used as a waste management tool by municipalities. The distribution of the daily waste generation rates versus employment data, exhibited in the graphs for each SIC sector, could enable municipal waste management personnel to prioritize their "remedial" waste reduction efforts by planning to visit those companies whose waste generation rates seem out of line with the general waste-to-employee relationship.

SECTION 1

INTRODUCTION & LITERATURE REVIEW

1.0 INTRODUCTION & LITERATURE REVIEW

1.1 Introduction

In recognition of a pressing need to improve the way in which waste is managed in Ontario, the Ontario Ministry of the Environment has initiated programs and established specific goals designed to ensure the development of innovative and integrated waste management systems. For example, the Ministry has issued Terms of Reference and assisted in the funding of Waste Management Master Planning for municipalities. Specific objectives for diverting significant amounts of waste from disposal through reduction, reuse and recycling activities (25% by 1992 and 50% by 2000) have also been announced by the Government of Ontario.

In order to effectively plan and design waste management systems that will achieve those goals, reasonably accurate estimates of the types and quantities of waste must be available. For example, the design of material recovery facilities that will receive and process waste must be compatible with the range of wastes anticipated to be received by the facility.

The Ministry of the Environment contracted Gore & Storrie Limited, in association with Decima Research Limited, to develop and test methodologies that would assist waste management planners and municipalities in deriving reasonable estimates of the material composition and generation rate of wastes from residential and commercial sources. The findings of that study are presented in three volumes:

Volume I - Residential
Volume II - Commercial
Volume III - Procedures Manual

For the commercial portion of the Ontario Waste Composition Study (Waterloo Study), the Regional Municipality of Waterloo (Region/Waterloo) was used as a sample municipality for the development and field trial of a methodology for estimating the type and quantity of waste generated by a variety of different types of commercial enterprises; i.e., those firms in the private sector that provide goods and services for consumers. Although these activities may be concentrated at a small number of locations within the urban area, such as "downtown", or a regional mall, the aggregate amount of commercial activity is very closely related to both the number of households and household income in the urban area. Commercial waste, in this sense, can be closely related to residential waste. Both waste streams stem from the same processes of consumption.

The Waterloo Study focused on the commercial activities that are most closely linked to residential requirements. The waste generation from office buildings is an important component; but it is difficult to distinguish offices that serve local residents (e.g., a legal firm) from those that serve the province as a whole (e.g., an insurance company). Wholesale activities, while part of the commercial waste system, also serve larger spacial units. They are too varied in their size and function to fit into the present sampling framework. They must be studied elsewhere, when a community studies the entire waste stream in their area. A review of relevant literature and consultation with experts in the fields of employment, commercial structure, demographics and waste management indicated that commercial waste generation is related to the number of employees at a particular commercial establishment.

The method was developed during the winter of 1989/1990 and applied in the Waterloo Study in the spring and summer of 1990. The study used the extensive information on the amount and composition of commercial employment provided by Statistics Canada and local government agencies to define a sampling framework for the field work.

Commercial activity in Canada is organized by the Standard Industrial Classification (SIC) established by Statistics Canada. This classification can be used as the basis for reporting waste composition and per employee generation rate data. Before beginning a waste composition field study, the commercial business SIC codes should be reviewed with respect to retail service activities to determine whether certain sectors can be grouped together.

The Census of Canada (1986) gathered information about occupation, type of employment and place of work from a twenty percent (20%) sample of households.

These data provide information about the number of employees in 36 different commercial sectors within each of the urban census areas in Ontario. Canada Census updates its census information every five years.

In the Waterloo Study, a representative sample of businesses from the SIC groupings were identified and approached by the study team to gain permission to include them in the study. Data were then gathered on the composition of the waste stream from each SIC grouping, and an estimate of the average generation rate of total waste per employee was made for each of the SIC groupings.

This manual describes a methodology for measuring waste generation and waste composition for commercial activities, as defined above. For a number of reasons, the commercial composition study method is more complex than that for residential sources described in Part A. First, when developing the method very little published literature was available for commercial activities (none for Canada in recent years) and therefore the research team had little a priori knowledge of expected values or variance to guide the design of an efficient sampling framework. Second, commercial activities are characterized by very high variance, relative to the residential sector. That variance is observed in waste generation both within and among the various retail and service sectors. There is also a wide range in store size (measured in level of sales or employment) within these sectors that must be taken into account. These variations mean that a much larger number of samples are required in order to provide the same degree of reliability obtained in the study on residential waste generation. Third, while detailed descriptions of household characteristics are provided by the Census of Canada, together with a variety of forecasts of growth and change provided by market research firms and government agencies, it is difficult to identify even the base population for a sample of commercial activities. It is not common for a single data source to provide counts or lists of the number of supermarkets or barber shops within a municipality. Sample locations must be identified in the field; extrapolations to obtain municipal or regional totals requires elaborate assumptions and indirect procedures.

Nonetheless, this manual describes a workable method to estimate overall waste generation and major components of the waste stream. While many more sample points than what was analyzed in the Waterloo Study will be required to increase the precision of estimates of waste streams for specific commercial activities, studies at the municipal level will benefit from the effect of aggregation in which hundreds or thousands of activities may be averaged together. This manual also provides a methodology for future studies that overcomes each of the difficulties identified earlier through future refinement of the method. Data on commercial waste generation and composition are now available to guide the design of waste sampling procedures (see Volume II for further information). The identification of high waste generation activities in Volume II permits agencies to target waste reduction and recycling programs on these activities. The difficulties, due to varying store size and unavailable data on the population of stores, have been overcome in the Waterloo Study by focusing on number of employees as the key measure that connects the sample observation to the overall data analysis and ultimately to the aggregate waste generation by the municipality. The number of employees in each SIC code is listed by Statistics Canada in their data base.

It would have been possible to restrict the Waterloo Study to just a few well chosen SIC groups in order to achieve greater confidence in the waste estimates. However, a broader study was chosen in order to assess the variances encountered in various SIC groups. This choice will benefit subsequent researchers who can target their efforts to develop and enhance a data base of waste generation for commercial activities in Ontario.

1.2 Literature Review

The results of the literature review as conducted in Volume II are presented in this manual as follows for convenience to the reader.

In the past, the Bird & Hale report (ref. 2) has been used as the baseline study for waste composition information on the municipal solid waste stream in Ontario. In the Bird & Hale study, the average annual composition of municipal solid waste entering landfill sites, transfer stations and incinerators, in Toronto, was derived from samples obtained during spring, summer, winter and fall. Twelve visits were made to six sites between October, 1976 and September, 1977, with two visits apiece at: Commissioners Street Incinerator, Ingram Incinerator, Dufferin Incinerator, Beare Road

Landfill Site, Bermondsey Transfer Station and Wellington Incinerator. Sample weights of municipal solid waste ranged up to 400 lbs. (180.7 kg).

Municipal solid waste has been traditionally defined as a combination of waste from residential and commercial sources, so the Bird & Hale study--which collected and reported on this combined municipal solid waste data--does not serve as a suitable baseline for the Waterloo Study which focused on the commercial activities that are related to residential consumption.

The earliest studies of the composition of commercial solid waste were reported by Peter Middleton & Associates (ref. 11). They briefly described three studies: Louisville (1970), Proctor & Redfern (1972) and Proctor & Redfern (1975), each based on questionnaires sent out to commercial businesses. The Louisville study reportedly divided the commercial sector into 18 different categories but regrettably this detail was not provided in the main report or appendix. The same is true of the two Proctor & Redfern reports. The questionnaires reportedly contained information on the categories of commercial businesses, but the information was reportedly lost (ref. 11).

Franke (ref. 5) described the general composition of the commercial waste stream in Cologne, Germany (1980/81 data) and Evans (ref. 4) reported the weight and volume of components in the waste streams from "retail", restaurants and office towers in Toronto (1984 data). More recently, Rhyner & Green (ref. 14) compared published literature data on per capita or per employee waste generation rates for residential, commercial, industrial and construction/demolition wastes with actual waste data that they were obtaining at county-owned landfill sites in Brown County, Wisconsin. Annual solid waste generation estimates were calculated for a number of SIC codes in the commercial sector. Rhyner & Green's estimates of the annual generation of commercial refuse, using a daily employee generation rate of 0.73-0.77 kg and county employment data, was within 15% of the "actual quantity". Table 1 summarizes the available information on the composition of commercial waste streams, from sources reported above.

A key paper that became the basis for the data gathering procedures developed in the Waterloo Study was published in 1971 by DeGeare & Ongerth (ref. 3). The

TABLE 1 COMPARISON OF WASTE COMPOSITION INFORMATION FOR THE COMMERCIAL SECTOR - PUBLISHED DATA[1] (PERCENT OF TOTAL)

Material	Proctor & Redfern (1972; 1975)	Evans (1985)			Louisville (1970)	Liblit (1990)					Franke (1987)
		Retail	Restaurant	Office Towers		Retail Trade	Restaurant	Office	School	Government	
Newsprint		6.2	2.7	6.3		2.9	2.5	3.6	3.3	6.7	
Brown Paper		2.8	2.9	8.6							27 total paper
OCC	51 - 65 total paper	16.5	4.0	2.9		22.0	16.6	11.5	11.6	8.4	
Fine Paper		15.4	15.4	66.9		1.4		10.6	6.3	7.2	
Other Paper		24.3	22.5	10.6		15.2	18.5	38.5	26.6	31.5	
Food Waste		9.6	42.9	1.1		8.1	36.0	3.0	14.0	3.2	10 organics
Vegetation		0.0	0.0	0.0							
Plastic	1 - 2	19.1	4.8	1.1	9.4	12.0	13.7	4.3	5.1	3.5	9
Textile/Cloth		2.0	0.0	0.1							
Wood		0.9	0.0	0.1		10.7	0.6	7.8	21.0	20.0	11
Other Combustibles		1.1	0.6	0.8							
Ferrous Metals		1.05	1.7	0.4		19.7	4.2	2.4	3.9	9.0	
Non-ferrous metals		0.1	0.3	0.1		0.8	0.7	0.5	1.9	0.8	3 metals & glass
Glass	1 - 4	0.75	1.8	0.7	11.3	2.5	5.9	3.9	3.2	2.7	
Other non-combustibles		0.3	0.6	0.3							
Inert Materials											12
Production Wastes (Rubber, rags etc)											12
Other ("household -like" wastes)											15
Miscellaneous	1.1 - 17[2]					4.7	2.3	13.9	3.1	7.0	

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[1] Data are given as percentages of the commercial waste stream. Canadian studies: Proctor & Redfern (1972; 1975), Evans (1985); U.S.A. studies: Louisville (1970), Liblit (1990); Germany: Franke (1987).

[2] Includes 12% construction wastes

authors explored the relationship between waste generation in clothing, drug, grocery, hardware stores, and restaurants as a function of a number of variables indicative of the physical and operational characteristics of commercial establishments. For example: (1) number of hours open per week; (2) number of business days open per week; (3) average annual gross receipts; (4) physical area of store, in square feet; (5) average inventory in dollars; (6) equipment value, in dollars; (7) number of delivery days per week; and (8) number of employees. Number of employees and store hours were the two variables that gave the best prediction of the waste generation rate for premises in the commercial sectors under study.

DeGeare and Ongerth, using "multiple stepwise regression analyses", demonstrated that the generation of commercial solid waste was found to be most closely related to the number of employees, hours open, and type of establishment involved. Graphs illustrating the correlation between actual and predicted waste quantities from the DeGeare and Ongerth study are reproduced in Appendix A.

DeGeare and Ongerth noted two points which clarify the relationship between waste generation and company employment. First, employment is a function of the intensity of retail activity; i.e., a small store with few customers will require a smaller sales staff than a larger store that serves a large clientele. Second, the items sold by stores are delivered in bulk, in packages, cartons, and other containers, with the individual items placed on shelves or otherwise displayed. Taken together, one can see that as the size of a store's staff increases to serve increasing numbers of customers (and sales), the quantity of goods delivered to the store will grow in response to customer demand and the amount of bulk packaging and related administrative wastes will also increase.

The focus on waste generation per employee that is evident in the literature fits well with another reference that examines consumer behaviour and commercial structure (Jones & Simmons, ref. 8). This reference demonstrates that the amount of commercial activity is highly predictable from information about the size and income level of the market. Given the number of households and average income level in any municipality, it is possible to project first, the patterns of consumer expenditure, from toothpaste to bank deposits, in great detail; and second, to calculate the level and composition of commercial activity. Furthermore, the different measures of commercial activity (i.e., number of stores, floor area, retail sales, number of employees) are all closely interrelated. Employment happens to be the most frequently measured and readily obtained. It provides the key link between the samples from the field work and the larger municipal waste system. When one determines the waste generation per employee for a SIC group, this generation rate can be extrapolated, via Statistics Canada data on total employment in the SIC sector to get the waste generation rate for the entire company. It is then possible to determine whether a reasonable amount of waste is being disposed at a given company as compared to an average waste generation rate for a company of similar size in the same SIC sector.

The authors would like to point out that they discovered a paucity of information pertaining to this subject and have made every attempt to locate and examine all relative material.

SECTION 2

OVERVIEW OF METHODOLOGY

2.0 OVERVIEW OF METHODOLOGY

The general approach used in the Waterloo Study included the following stages which are also summarized in Figure 1. This methodology is recommended for continued use and further refinement with growth of Ontario's waste generation and composition database:

1. Project Initiation and Selection of SIC Code Major Study Groups

   Review of procedures contained in this manual and any other relevant literature.

   Obtain and review census information on commercial businesses from Statistics Canada. Define specific commercial types. Review commercial business SIC codes with respect to retail/service activities to determine whether certain activities could be grouped together. Although the commodities or services provided by businesses may differ, similarities in the waste streams permit the aggregation of sectors thereby reducing the field work required.

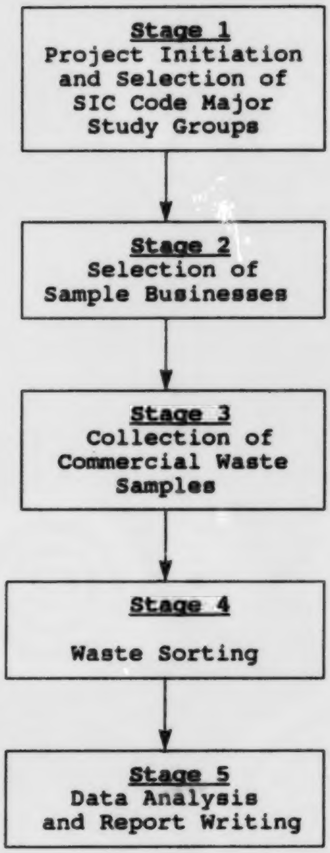
   Prior to finalizing a strategy, the current waste management practices in the municipality undergoing the waste composition study must be understood.

2. Selection of Commercial Businesses

   Determine a reasonable number of samples and the size of those samples that can be taken given the applicable monetary and time constraints for the study.

   Contact the chosen businesses to ensure that the locations meet the basic criteria as described in chapter 6. If necessary, arrange a site visit, to assist in deciding whether a particular location is suitable for sampling.

FIGURE 1
STAGES OF COMMERCIAL WASTE
COMPOSITION STUDY


Stage 1
Project Initiation and Selection of SIC Code Major Study Groups
Stage 2
Selection of Sample Businesses
Stage 3
Collection of Commercial Waste Samples
Stage 4
Waste Sorting
Stage 5
Data Analysis and Report Writing

3. Collection of Commercial Waste Samples

Arrangements and scheduling for collection of commercial waste samples should be made prior to the commencement of the field work. Commercial wastes should be weighed, collected and transported to a sorting area.

Collection of waste samples will vary depending upon whether the waste is loose or compacted. Once the waste sample is extracted from the refuse bin and weighed, the sample should be transported to a sorting area.

4. Waste Sorting

Before actual sorting takes place, it is necessary to set-up the necessary sorting equipment and develop a time efficient and accurate sorting strategy.

Obtain information on the composition of the waste stream from each SIC by sorting and weighing the various material types. An example of a waste composition data field sheet is provided in section 8. Whenever possible, recyclable material should be deposited at the local recycling depot.

5. Data Analysis and Report Writing

Estimate the average generation rate of total waste per employee for each of the commercial groups. In the Waterloo Study, waste was collected from a number of premises in each SIC group, attempting to cover a range of small and large companies. Assess the relationship between waste generation and employment by regression analyses when sample size permits.

Analyze both Statistics Canada employment data and the municipality's planning information to generate an estimate of the total number of people employed in the commercial groupings for which waste generation estimates are obtained.

Multiply the total municipal employment figure by the employee waste generation rate for each SIC group to estimate the quantity of waste generated by each of the commercial activities. The sum of the waste estimates for the groups gives an estimate of waste generation by a large segment of the commercial sector in the municipality.

SECTION 3

WASTE STUDY PARAMETERS AND CONSIDERATIONS

3.0 WASTE STUDY PARAMETERS AND CONSIDERATIONS

Conducting a waste composition and generation study requires careful planning with regard to the type of data required, and how the data will be collected.

3.1 Required Waste Generation Rate and Waste Composition Data

The data collected in a waste composition study fall into two categories:

1. per employee generation rate information; and
2. percent composition of the waste by component materials.

3.1.1 Waste Generation Rate

For the purposes of the Waterloo Study the commercial waste generation rate was defined as kilograms per employee per day (kg/employee/day). These units can easily be multiplied by constants to obtain weekly, monthly, or yearly generation rates in kilograms or tonnes. As well, a total tonnage of waste generated for the municipality can be calculated by multiplying by the total number of employees in the municipality by the per employee generation rate.

3.1.2 Waste Composition

The percent composition of waste by its material components is dependent on the waste stream studied, and on the definition of the categories of material used.

The waste component categories used in the Waterloo Study were based in part on the physical or chemical make-up of the component and in part on the form the waste material takes. As such there are several subcategories for most materials. The subcategories can be based on physical and chemical make-up, such as those for paper (fine paper, newspaper, corrugated cardboard etc.), or the sub-categories can be based on form and usage such as with ferrous metal (food containers, returnable beverage containers, non-food containers). A list of the waste component categories and sub categories used in the Waterloo Study is given in Table 2.

TABLE 2: WASTE COMPOSITION DATA FIELD SHEET

Town:
SIC:
Sample # :
Collection Dates:

Ministry of the Environment
Waste Composition Study

GORE & STORRIE LIMITED

(1) Paper (a) Newsprint				
(b) Fine Paper / CPO / Ledger				
(c) Magazines / Flyers				
(d) Waxed / Plastic / Mixed				
(e) Boxboard				
(f) Kraft				
(g) Wallpaper				
(h) OCC				
(i) Tissues				
(2) Glass (a) Beer (i) refillable				
(ii) non-refillable				
(b) Liquor & Wine Containers				
(c) Food Containers				
(d) Soft Drink (i) refillable				
(ii) non-refillable				
(e) Other Containers				
(f) Plate				
(g) Other				
(3) Ferrous (a) Soft Drink Containers				
(b) Food Containers				
(c) Beer Cans (i) returnable				
(ii) non-returnable				
(d) Aerosol Cans				
(e) Other				
(4) Non-Ferrous (a) Beer Cans (i) returnable				
(ii) non-returnable				
(iii) American				
(b) Soft Drink Containers				
(c) Other Packaging				
(d) Aluminum				
(e) Other				
(5) Plastics (a) Polyolefins				
(b) PVC				
(c) Polystyrene				
(d) ABS				
(e) PET				
(f) Mixed Blend Plastic				
(g) Coated Plastic				
(i) Nylon				
(i) Vinyl				
(6) Organic (a) Food Waste / Rodent Bedding				
(b) Yard Waste				
(7) Wood				
(8) Ceramics / Rubble / Fiberglass / Gypsum Board / Asbestos				
(9) Diapers				
(10) Textiles/Leather/Rubber				
(11) Hazardous Wastes (a) Paints / Solvents				
(b) Waste Oils				
(c) Pesticides/Herbicides				
(12) Dry Cell Batteries				
(13) Kitty Litter				
(14) Miscellaneous				
	TOTAL kg		TOTAL kg	

Note that in Table 2 there are no categories for bulky items such as used appliances and furniture. These items are usually collected separately from regular waste.

3.2 Basis for Defining Commercial Waste Generation

A key paper that became the basis for the data gathering procedures developed in the Waterloo Study was published by DeGeare & Ongerth (ref. 3). The authors explored the relationship between waste generation in clothing, drug, grocery, hardware stores, and restaurants as a function of a number of variables indicative of the physical and operational characteristics of commercial establishments. Number of employees and store hours were the two variables that had the best prediction of the waste generation rate for premises in the commercial sectors under study.

Number of employees is the variable that is most readily available and hence was utilized in the Waterloo Study. First, Standard Industrial Classification (SIC) Codes, available from Canada Census, were used to describe business types. Canada Census data and local planning information were then used to determine the number of employees per SIC division and per business establishment. Finally, this information was used to select locations for the collection of waste samples.

SECTION 4

MANPOWER, EQUIPMENT AND COST

4.0 MANPOWER, EQUIPMENT AND COST

The following is a description of the manpower requirements, necessary equipment and costs associated with conducting a waste composition study. In the manpower section a dollar value of the wage for the workers is not specified as this must be determined by the municipality conducting the study. Instead, only an estimation of the number of work days and hours required to complete the study is given. Lists of required and optional equipment is provided, but no dollar amount for the purchase or rental of this equipment is given. These details should be carefully considered by any municipality undertaking a waste composition study.

4.1 Personnel

For the Waterloo study the field crew consisted of three people. When collecting waste, one person empties the bin, another weighs the refuse, and the third person fills out the data sheets (sample weight, waste stream description, any unique miscellaneous notes, etc.).

A basic background in science or engineering was deemed desirable because of the quantitative aspect of the work. A waste composition study is an exercise in quantitative analysis of commercial wastes conducted under field conditions, using skills learned in technical courses that are part of science and engineering education.

A "laboratory" work ethic should be emphasized in terms of accurate data acquisition/manipulation and maintaining as clean as possible work environment (ie. regularly rinsing garbage cans, cleaning waste bin area, sweeping back of truck, etc.). Further, individuals should have an avid concern for the environment and as such when recyclable materials are found in waste bins they should attempt to bring those materials to the recycling area whenever possible.

In addition to the field crew, a project manager is required. That person must have a technical background and a high level of respect and responsibility within the municipality's works and engineering department. The project leader (in absence of an outside consultant) will be responsible for performing the calculations necessary to define the sample ranges, determine the sample locations, contact and liaison with waste haulers, ensure good records are kept, and general project management. The project manager will also be responsible for generating a report presenting the results of the study.

It is imperative that the crew receive instructions in health and safety prior to commencing the field studies. All members must be alert for potential dangers, eg. traffic, explosive/acidic cans, etc. A similar health and safety program to those utilized to train waste collectors and landfill technicians could be adapted to suit the needs of the waste composition study.

The crew must also receive instructions on recognizing waste categories. Because the focus of the Waterloo Study was on method development, the crew was instructed to be critical of their procedures. The crew should be encouraged to set aside all materials that were difficult to categorize, describe them in writing and include them in a 'miscellaneous' category.

4.2 Equipment Used in the Waste Study

An equipment list similar to that used in the Waterloo Study is suggested for future waste composition studies, but should not be regarded as an exhaustive list. The following list of equipment includes a rented vehicle and purchased equipment utilized in the Waterloo Study:

one - 4.3 m. (14 ft.) cube van (for collection of bagged refuse);

one - electronic platform scale (150 kg capacity, Accu Weigh Model PAK-150 (electronic, battery operated scale with digital read-out), Exact Weight Scale Inc., Toronto, Ontario);

one -electronic bench scale (500 g capacity, Accurate, model 3670)

one - chicken wire "crib": 1.2 m. (4 ft.) x 1.2 m. (4 ft.) x 1.3 cm. (1/2 in.) plywood base; 0.6 m. (2 ft.) high chicken wire and 2.5 cm. (1 in.) x 5.1 cm.(2 in.) furring sides. Nailed to the underside of the crib floor was a square frame which permitted the crib to be centred on the bed of the platform scale; the crib was used for weighing the refuse as it was being collected from the firms;

40 - 30 litre polyethylene garbage cans; these were used as containers into which sorted refuse was placed;

one - broad-mouth aluminum shovel; used for cleaning up spills;

one - broom; used for cleaning up spills and sweeping out the vehicle;

one - staple gun and 0.95 cm. (3/8 in.) staples for construction and repair of chicken wire dividers and crib;

one - claw hammer; 5.1 cm. (2 in.) common nails: used in the construction of the crib.

Personal Safety Equipment:

a) Certified steel toe safety boots
b) Coveralls
c) Orange safety vests
d) Hard hats (at the landfill)
f) Rubber safety gloves
g) Particle filter masks (dust in garbage bins)
h) Complete first aid kit (in truck)
i) Tetanus/polio vaccination
(optional: diphtheria, Hepatitis A and B).

Health (including personal hygiene) and safety must be stressed at all times during the study. It is important to remember that within each bag/bin of garbage there may be disease carrying organisms, sharp objects including hypodermic needles, containers that may explode, combustibles, corrosive and caustic agents, harmful chemicals, and dust. Caution and common sense should be exercised.

4.2.1 Seasonal Effects on Equipment Requirements - Shelter and Clothing

The season of the year in which the study is conducted has a great bearing on the clothing and shelter requirements of the field crew, and general carrying out of the study.

For several reasons it may be advisable to conduct the study during the fall or winter months. The waste will have less odour and fewer maggots and flies at this time of year. In addition the cool or freezing temperatures will keep the organic fraction of the waste from rotting which will make the work more manageable from an objective and aesthetic standpoint. The cooler weather will also reduce the amount of moisture lost by the waste, due to evaporation, from the time the sample is collected to the time it is actually sorted (several days in some cases).

If the study is conducted in the autumn or winter months some form of shelter is required by the field crew while sorting the waste. Shelter is required to protect the field crew (and the waste samples!) from wind, rain, snow and cold. In the summer protection from the wind, rain, and direct sun will be required.

In addition to a sheltered work space, the sorting crew must be provided with a warm and dry break-room as well as washroom facilities.

4.3 Cost of Conducting a Typical Commercial Waste Study

The unique nature of each municipality's commercial structure precludes the development of a generic guideline budget of time requirements and costs for a commercial waste study. Formula for estimating costs are not provided in this manual, however some indication of time requirements will be made.

The municipality undertaking commercial waste study must determine the number of establishments required to adequately characterize the waste from that municipality's business community. The required number of samples for statistical reliability was not determined during the Ontario Waste Composition Study. The limiting factor for the number of establishments sampled in a municipality will be the time and monetary constraints of the study.

The following is an estimate of the cost associated with conducting a commercial waste composition study with a minimal number of samples.

4.3.1 Estimated Personnel Time and Disbursement/Equipment Requirements

STAGE 1: PROJECT INITIATION AND SELECTION OF SIC CODE MAJOR STUDY GROUPS

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Project Initiation	Project Manager[1]	4.0
Task: Obtaining/Reviewing Census and Local Commercial Employment Data	Project Manager Project Assistant[2]	2.0 2.0
Task: Review and Selection of SIC Code Major Study Groups	Project Manager	2.0
SUB-TOTAL	Project Manager Project Assistant	8.0 2.0
DISBURSEMENTS:	Statistics Canada Service Fee, Travel, Telephone, Office Supplies, and Computer time.	

continued.../

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[1] The Project Manager will typically be a person from the Municipal engineering Department or some other member of the Municipal Staff familiar with Waste Management procedures.

[2] The Project Assistant would ideally be a member of the field crew and also a member of the municipal staff familiar with waste management procedures.

4.3.1 Estimated Personnel Time and Disbursement/Equipment Requirements

STAGE 2: SELECTION OF BUSINESSES

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Selection of Businesses within the Chosen SIC Groups	Project Manager	2.0
	Project Assistant	2.0
Task: Contact Businesses to Obtain Permission and Arrange Sample Collection	Project Manager	6.0
	Project Assistant	6.0
SUB-TOTAL:	Project Manager	8.0
	Project Assistant	8.0
DISBURSEMENTS:	Travel, Telephone, and Office Supplies	

Note: Stage 1 and Stage 2 can be carried out by the Project Manager, or in association with an outside consulting agency familiar with Census of Canada data and sampling procedures.

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4.3.1 Estimated Personnel Time and Disbursement Requirements

STAGE 3: COLLECTION OF COMMERCIAL WASTE SAMPLES

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Field Crew Training	Project Manager Field Crew[3] (of 4)	2.0 4.0
Task: Obtaining/Constructing All Required Equipment and Supplies	Project Manager Project Assistant	3.0 3.0
(A) Once per week commercial waste collection.	Project Manager	0.5
Task: Collection of Waste Sample	Field Crew (of 4)	2.0[4]
(B) More than once per week municipal waste collection	Project Manager	1.0
Task: Collection of Waste Sample	Field Crew (of 4)	4.0

SUB-TOTAL:

(A) Once per week waste collection	
Project Manager	5.5
Project Assistant	3.0
Field Crew	6.0
(B) Twice per week waste collection	
Project Manager	6.0
Project Assistant	3.0
Field Crew	8.0

DISBURSEMENTS: Telephone, Travel Cost and Office Supplies.

EQUIPMENT: Equipment purchases and rentals including rental of vehicles, portable weigh scales and safety equipment.

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[3] The four (4) person field crew would ideally be composed of persons dedicated to the study and familiar with waste management procedures, and aware of the need for accurate waste management information. The field crew members should have some education in standard laboratory skills such as proper use of scales, accurate record keeping and the necessity of replication of study results. The 4 person field crew may include the project assistant, who could act as a supervisor in the absence of the project Manager.

[4] Two to three samples per half-day depending on size of business entity.

4.3.1 Estimated Personnel Time and Disbursement/Equipment Requirements

STAGE 4: WASTE SORTING AND ANALYSIS

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Field Crew Training - Sorting and Classifying Waste and Data Recording	Project Manager	1.0
	Field Crew (of 4)	2.0
Task: Waste Sorting	Project Manager	0.25
	Field Crew (of 4)	2.0[5]
SUB-TOTAL:	Project Manager	1.25
	Field Crew (of 4)	4.0

DISBURSEMENTS: Tipping/disposal fee for sorted waste after analysis, telephone, travel cost and office supplies.

EQUIPMENT: Equipment purchases and rentals including obtaining shelter for the field crew, provision of safety equipment, and tetanus/polio/diphtheria immunization of field crew.

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[5] Two to three samples per half-day depending upon the size of the business entity.

4.3.1 Estimated Personnel Time and Disbursement/Equipment Requirements

STAGE 5: DATA ANALYSIS AND REPORT WRITING

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Data Entry to Spreadsheets	Project Assistant	1.0+[6]
Task: Data Analysis, Calculations, Report Writing and Typing	Project Manager	10.0
	Project Assistant	3.0
SUB-TOTAL:	Project Manager	10.0
	Project Assistant	4.0+

DISBURSEMENTS: Office supplies, and computer time

WORK DAYS TOTAL

Administrative:	Project Manager	32.75
	Project Assistant	17.0
	Project Crew	10.0

Note: For twice per week collection add 1.5 hours to project manager total and 2.0 hours to field crew total.

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[6] Up to 10 samples per day.

SECTION 5

STAGE 1 - PROJECT INITIATION AND SELECTION OF SIC MAJOR STUDY GROUPS

5.0 STAGE 1 - PROJECT INITIATION AND SELECTION OF SIC MAJOR STUDY GROUPS

5.1 Obtaining Census Canada Information

Obtaining Canada Census data is the starting point for defining business activities. The Census of Canada gathers information about occupation, type of firm and place of work from a twenty percent sample of households. A special tabulation of these data provides information about the number of employees in 36 different commercial sectors for each CMA in Ontario. The basic tabulation is by place of residence, which is not a problem for a regional municipality as a whole, but other "journey-to-work" tabulations indicate how this employment is allocated by municipality within the Region. These data can be updated by reference to the monthly survey of "The Labour Force" which estimates employment for each CMA.

Census data is collected every five years and is available from Statistics Canada for a nominal service fee. In Ontario the Statistics Canada library has the following address:

Statistics Canada, Toronto
25 St. Clair Avenue East
Toronto, Ontario
M4T 1M4

Data can be obtained in printed format or on computer disk or tape. Larger municipalities may find the computer disk format to be more useful owing to the large volume of data required.

5.1.1 Defining Commercial Activity

When driving along a commercial strip, through a central business district (CBD), or past an industrial park, a casual observation creates a general mental picture of a wide variety of commercial establishments. Modern society reflects the entrenched selling and buying mentality in which people recognize the various commercial facilities that are available for their disposable incomes. However, in the context of developing a well structured waste composition sample program, a range of commercial establishments must be categorically defined in terms of specific socioeconomic function.

Statistics Canada, as part of its Standard Industrial Classification (SIC), is a main source for developing an organized sample pool that reflects existing commercial and industrial infrastructure (ref. 15). In its SIC catalogue Statistics Canada has disaggregated the universe of economic activity into 18 primary industrial divisions (Table 3) that contain major sub-divisions or specifically "Major Groups" (Table 4). These Major Groups are further delineated into areas of specific commercial functions. An example is as follows:

> Division J represents the retail trade industries. Within this division are numerous major groups, such as Major Group 60 - food, beverage, and drug industries (retail). This is further delineated into specific commercial establishments including SIC #6011 super markets and SIC #6012 grocery stores.

The hierarchial SIC category arrangement of business and industry provides a well organized sample framework to develop a diverse and accurate representative sample pool.

Thus, the classification provides the basis for the selection of commercial activities to be studied, and for the extrapolation of the sample results into municipal totals. The same classification is used for all of Statistics Canada's economic surveys. It enables us to apply data from the Census of Canada, or the monthly Labour Force Survey, to the task of estimating waste generation for aggregations of commercial activities.

5.1.2 Commercial Employment in the Regional Municipality of Waterloo

Within the universe of economic activity, the Waterloo Study focused on six divisions: J, K, L, M, Q, and R (as indicated with asterisks on Table 3). The activities in these divisions take place within the private sector and serve local residential communities. Thus they are located within the communities they serve, and the number and size of these activities are quite predictable from a knowledge

TABLE 3: LIST OF SIC DIVISIONS

Division A	Agricultural and Related Service Industries
Division B	Fishing and Trapping Industries
Division C	Logging and Forestry Industries
Division D	Mining (Including Milling), Quarrying and Oil Well Industries
Division E	Manufacturing Industries *
Division F	Construction Industries
Division G	Transportation and Storage Industries
Division H	Communication and Other Utility Industries *
Division I	Wholesale Trade Industries *
Division J	Retail Trade Industries **
Division K	Finance and Insurance Industries **
Division L	Real Estate Operator and Insurance Industries **
Division M	Business Service Industries **
Division N	Government Service Industries
Division O	Educational Service Industries
Division P	Health and Social Service Industries
Division Q	Accommodation, Food and Beverage Service ** Industries
Division R	Other Service Industries **

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* Low emphasis in study

** High emphasis in study

TABLE 4: LIST OF THE 13 SIC CODE MAJOR STUDY GROUPS

Major Group	Description
17	- Leather and Allied Products Industries.
28	- Printing, Publishing and Allied Industries.
48	- Communications Industry.
56[1]	- Metals, Hardware Plumbing, Heating and Building Materials Industry, Wholesale
60	- Food, Beverage and Drug Industries, Retail.
61	- Shoe, Apparel, Fabric and Yarn Industries, Retail.
62	- Household Furniture, Appliances and Furnishings Industries, Retail.
63	- Automotive Vehicles, Parts and Accessories Industries, Sales and Service.
65	- Other Retail Store Industries (i.e. Florist Shops, Jewellery Stores etc.).
70	- Deposit Accepting Intermediary Industries (i.e. Banks, Trust Companies).
91	- Accommodation Service Industries.
92	- Food and Beverage Service Industries.
96	- Amusement and Recreational Service Industries.

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[1] Retail hardware and building supplies are designated as wholesale activities in the SIC classification

of the size and characteristics of the residential population. Within these six divisions, Statistics Canada identifies hundreds of smaller groups of specialized activities each of which includes a large number of stores that provide similar goods and services and operate in the same fashion. Given a base population of activities, these stores can be sampled and extrapolated to provide overall estimates of waste generation.

In contrast, the primary manufacturing and wholesaling divisions are fewer in number and far more diverse in size and specialization. This is because they are not directly tied to or restricted by the size and requirements of local markets; i.e., those in close spatial proximity to the manufacturing or wholesaling activity. A factory may produce goods for markets across the continent using processes and materials that are quite different from a neighbouring plant--even if the plant has the same industrial classification. Some municipalities have many factories; others have virtually none. Waste generation by such activities must be studied on a site-by-site basis.

While many educational, health, and local governmental services serve local residents, some activities, such as universities or major hospitals, were excluded from the Waterloo Study. As well, the lawn and yard maintenance service sector was not sampled in the Waterloo Study.

The six divisions in the Waterloo Study included 32.8 percent of the total employment in the Regional Municipality of Waterloo. Divisions J and Q, which were sampled most thoroughly, included 18.1 percent of the total. Commercial activities are numerous and represent a significant component of the economic base of every community.

Statistics Canada further disaggregates these six divisions of commercial activity (which were included in the Waterloo Study) into 27, two-digit SIC codes, each representing a familiar group of retail or service activities. In order to get the most information from a limited number of samples, these two-digit groups should be further aggregated and disaggregated as in the Waterloo Study as shown in Table 4. The general principle is to aggregate those groups that appear to have similar waste generation patterns, and to disaggregate those that have varied rates of waste generation. For example, the automotive group (SIC 63) can be disaggregated to reflect fundamentally different kinds of operations in dealerships, garages and gas stations. One group can be used to estimate other groups; for example, in the Waterloo Study Group 64 was estimated from the results for groups 61 and 62. Among financial services, only banks were sampled in the Waterloo Study. Hotels and restaurants were each disaggregated in the Waterloo Study to determine if different waste generation patterns could be identified.

In addition, in the Waterloo Study a limited number of samples explored economic activities lying outside the targeted divisions. Building supply stores (SIC 56) were sampled within the framework, but are formally classified as wholesale activities within the SIC. They are excluded from the expansion of the sample for the municipal total. The printing and publishing manufacturing group (SIC 28) was also sampled in the Waterloo Study.

5.1.3 Extrapolation of Sample Data to a Municipality

The task of extrapolating the results from the waste generation samples to project the waste generation for an entire area or regional municipality is complicated by the lack of information that describes the overall magnitude of commercial activity. There is no Census of Retail and Service Activity, or its equivalent. Instead, data on commercial employment can be obtained from several different sources and must be adapted to the particular study. The procedures used for this extrapolation may vary from place to place, depending on the mix of information that is available.

The starting point is the Census of Canada, 1986 (soon to be superseded by the 1991 version) for the residential population. For a twenty percent sample of households, each person over 15 is asked about employment; e.g., what kind of firm? These data are coded to the SIC categories. For each Census Metropolitan Area (CMA) how many people work in which kinds of activities is known. Unfortunately people do not always work in the same municipality where they live. If the municipality is isolated from other places (e.g., Timmins) the assumption can be made that the residents work in the same municipality that they reside; if it is embedded within a larger economic region (e.g., the City of Toronto or the City of Waterloo) further adjustments must be made. One could shift the scale of analysis from the smaller area municipality to the region as a whole (e.g., the Greater Toronto Area, the Region of Waterloo) or one could turn to other sources of data on employment. The Ministry of Transportation has compiled journey-to-work data for the major urban regions in Ontario that indicates how many people work in one community (e.g., the City of Cambridge) and live in another (e.g., the City of Waterloo), but these data are not broken down by SIC. Or there may be regional employment surveys that indicate how many jobs of various kinds are found in each component municipality--although they do not always use the same breakdown of commercial activities as Statistics Canada's SIC. The problem, then, is complex; and may require local expertise.

In the Waterloo Study, the starting point was the Census of Canada material, augmented by the Region of Waterloo employment survey to provide more spatial data, and Statistics Canada's Labour Force survey, to provide a temporal update. The amount of spatial or temporal detail required will depend on the application of the information.

While in the Waterloo Study there was no alternative to the use of employment data to link the waste generation sample to the projections for the municipalities, the relationship between employment and the volume of commercial activity is very strong (ref. 8). Salas, floor area, and employment are consistently linked together very closely. In the present work, employment is simply the total number of workers, both part-time and full-time--as defined by Statistics Canada. The ratio of part-time to full-time employees is consistent across each SIC sector, and the number of each type of employees should vary through time with the level of sales. Both employment and sales vary slightly from season to season (depending on the type of commercial activity). Early summer data (as used in the Waterloo study) provide a reasonable proxy for the annual levels as indicated by indices of seasonality computed by Statistics Canada (see ref. 16). These indices allow us to calibrate the seasonal effects at other times of the year.

5.2 Regional Municipality of Waterloo Planning Information

A discussion of the Regional Municipality of Waterloo planning information which was used in the Waterloo Study has been included as follows for information purposes.

The Regional Municipality of Waterloo, encompassing the cities of Kitchener, Waterloo and Cambridge, and four smaller Townships of Woolwich, Wilmot, Wellesley and North Dumphries, is located about 110 kilometres west of Toronto and about 60 kilometres northwest of Hamilton. The population of the Region (1988 Municipal Directory information) was 342,030. Information from an employment survey conducted by the Region's Planning Department provided additional information about the number of firms and employment in commercial activity in each of the local municipalities within the Region in 1989. The sectoral categories differ slightly from those used by Statistics Canada so the data could not be used directly in the estimate of waste generation. Instead, the information was used to estimate the share of Regional waste that is generated by each municipality.

Specific establishments within the Region of Waterloo were chosen, based on the selected SIC groups, by referring to local municipal business directories of Kitchener, Waterloo, and Cambridge. These sources provided the type of business, name of business, address/phone number, and number of employees. When deciding on the specific establishment to be sampled, the sample size in terms of the number of employees is important since for each SIC code grouping a range of different establishment sizes is necessary (e.g. small, medium, and large). Such a sample range, based on number of employees, provides a more accurate data analysis for waste composition and per capita waste generation (kg/employee/day). For example, SIC Major Group 60, food, beverage and drug industries (retail), provides the SIC code sub-groups SIC #6011 - supermarket (large number of employees ranging from 40 to 200), SIC #6012 - mid-size grocery store (medium number of employees ranging from 10 to 40 people), and SIC #6019 - other food stores i.e. convenient/specialty stores (small number of employees ranging from 1 to 10). It is not always possible to define such a sample range since it does not exist for all commercial establishments.

In addition, the yellow pages of the Bell Canada phone directory also contains a valuable up-to-date source of potential sample candidates. Finally, "the casual observation" driving to work in the morning, creates a mental note of commercial and industrial business locations where specific SIC code establishments can be incorporated into the sample pool.

5.3 Knowing Your Community - Current Waste Management Practices

The next parameter that must be known before beginning the waste study is the current waste management practices in the municipality.

The following information should be assessed:

1. waste collection frequency: once per week, or twice or more times per week;
2. collection routes and schedules;
3. collection practices and scheduling during holidays etc.;
4. presence of Blue Box programs or other recycling activities and days on which recyclable materials are collected;
5. presence of special waste collection programs such as spring and fall clean-up collections, leaf and yard-waste collections, bulky item collection days, white metal collections, hazardous waste collections and so on.

This information is needed to coordinate the collection of waste samples with regular waste collection so that conflicts do not occur, and to ensure that data are collected regarding special waste collections.

5.3.1 Waste Composition Variability

Does one expect a large variation in the composition of the waste streams generated by commercial businesses throughout the year? Given the "predictable character" of retail activities carried on within each SIC group, there is no reason to expect a significant variation in the composition of the waste generated by business within a given sector.

It is expected, however, that there may be variations in the quantity of waste with increases occurring at certain times of the year, e.g. Christmas holidays, year-end inventories, etc. However, retail activity is dependent on consumer habits. Consumer waste generation is reportedly consistent, varying +/-10% of a yearly average over three quarters of the time (cf. Vesilind & Rimer, ref. 17). The implication of the consistency is that seasonal variations in residential refuse generation patterns will be mirrored in many of the commercial retail sectors. Financial institutions may also exhibit predictable fluctuations in waste composition and/or quantity, that may be correlated with cyclic business-related activities.

5.3.2 Bulk Item and Special Collection Days

The snap-shot approach (relatively small number of samples taken for numerous SIC groups) to waste characterization which was utilized in the Waterloo Study precludes taking of any waste that would not be generated on a daily or weekly basis.

A similar "snap-shot" approach would require that special care be taken to identify special wastes or wastes that may not normally be present in the commercial establishment's waste stream. Several waste generation practices and "one-time" waste disposal occurrences can bias a random sample, especially when only a limited number of samples are taken from any one SIC group. This is a consideration where bulky items are present in the commercial waste stream.

A sampled commercial establishment may have unusual waste disposal occurrences during the study period. Note should be taken of the following:

- Items which are rarely disposed such as appliances or other bulk items may be present in the sampled waste. Large, one-time disposal items will bias the sample and hence the aggregated sample for the entire SIC group if the number of samples is small. When dividing the materials into respective waste composition categories, the large or heavy "one-time" items will raise the relative proportion of that material while decreasing the relative proportion of the other materials. When the item is clearly a "one-time" disposal occurrence that item should be weighed but recorded separately.

- Some material may be segregated for future recycling and set along-side with refuse awaiting disposal. These items should also be clearly identified and their weights recorded under the "recycled" waste category. As more and more materials are recycled or reused from commercial establishments, including materials excluded from a "blue box" program, additional care must be taken to identify and record the weights of such waste separately.

- Hazardous wastes, such as crank-case oil, paints, and solvents, may show up in the general refuse bin of various commercial establishments. Such wastes should be weighed and noted in the appropriate categories under the heading "hazardous waste" on the data collection sheets.

SECTION 6

STAGE 2 - SELECTION OF BUSINESSES

6.0 STAGE 2 - SELECTION OF BUSINESSES

6.1 Size and Number of Samples Required

6.1.1 Size of Samples Required

The size, i.e. weight, of the sample that must be taken to maintain statistical reliability depends on the variability of both the waste composition and the waste generation rates. If an estimate of the approximate percentage that a particular component contributes to the overall composition of waste is known and an estimate of the population standard deviation is known then the size of sample required may be calculated using the optimal sample size within clusters (ref. 19, Vol. I, p. 244). Nomograms reflecting this relationship were used to determine the size and number of samples required in the residential waste composition study. However, this relationship is not clearly defined for commercial wastes which are by-products from a variety of commercial activity. In the future, the lack of sample data from which reasonable estimates of waste composition and population standard deviations can be made will likely be rectified and a statically valid sample size may be determined.

The Waterloo Study was a pioneering study and as such no attempt was made to define a sample size. Waste was sampled from one week's accumulation. When the waste was placed at the curbside or loose in a dumpster the entire contents of the container was taken. When the waste sample was obtained from large compactor bins only half of the contents of the bins was sampled due to time constraints. As a result the weights of the samples ranged from 2.4 kg to 5782 kg.

6.1.2 Number of Samples Required

The number of samples that must be taken from each SIC group depends on the population standard deviation, the probability distribution associated with the population, and the desired level of precision. Due to a lack of historical information, the number of samples taken during the Waterloo Study was based on the availability of time and man-power. In the future, when commercial waste composition estimates are more readily available, it may be possible to utilize a similar formula to that used in the residential study in Volume I.

6.2 Contacting Businesses

The Waterloo Study field crew had considerable familiarity with a variety of businesses in the Region and they were able to recommend many companies to contact for the study; the Yellow Pages in the phone directory were also consulted for the names of firms. The decision on how best to approach businesses was left up to the field crew, after considering two alternatives: (a) contact by telephone and (b) direct company visits.

The field crew quickly realized that the most practical and efficient method of obtaining permission from local businesses to participate in the study was from a personal visit from the crew members themselves. The approach of contacting the firms by telephone is very time consuming and was inherently very unsuccessful. In the direct approach, store owners or managers can see first hand, who they would be dealing with. The waste study can be discussed in detail and questions can be answered and the logistical problems at each location can be assessed. A business card legitimizes the crew's intentions and initiates a good rapport between the field crew team and the business. In fact, in the Waterloo Study more than 90% of the businesses directly approached agreed to participate in the study.

The basic criteria required for sample locations are as follows:

- The commercial waste bin cannot be shared with another establishment in order to obtain a pure sample representation of one specific establishment.

- The waste bin must not contain an internal compacter since it is potentially dangerous for sampling (never enter a closed bin) and it would be very difficult to obtain the total bin refuse weight due to the densely compacted waste. Exceptions are made for external compactor bins, but only if absolutely necessary. The waste is still difficult to remove, but it is an open bin and if the compactor is turned off and the start key is removed the hazard is lessened.

- The waste bin must be safely accessible, ie. located in an area free of traffic or other potential hazards to the field crew.

The provision of such information, and if necessary an arranged site visit, will help decide whether a particular location is suitable for sampling. This will prevent unnecessary use of time for both the business and the study team.

SECTION 7

STAGE 3 - COLLECTION OF WASTE SAMPLES

7.0 STAGE 3 - COLLECTION OF WASTE SAMPLES

7.1 Scheduling Waste Collection

One objective of the Waterloo Study was to obtain a "snap shot" of the composition of waste generated in a week by commercial businesses. Therefore, waste collections for the study must be tailored to the waste collection for each business. In the simplest case (i.e., once a week collection), the crew might consider visiting the company 12 to 18 hours before the bulk-lift refuse bin is scheduled for dumping and removing the accumulated waste. Whenever Monday is the collection day, the crew will have to make their collection on Sunday.

Many businesses may have to be visited 3 or more times in order to obtain a week's worth of waste. In some cases, it may be necessary to have businesses store their waste, especially if the putrescible content was low, in order to save the crew repeated trips.

Sample scheduling must also consider the proximity of establishments from one another. Generally, two or three establishments may be sampled per day. It is time effective to schedule establishments that are close together on the same sampling day.

Other factors should be considered when developing a field sample schedule. Irregular activities, eg. festivals, renovations, will generate larger amounts of waste. Another factor involves the concern of management's preference for schedule time. Finally, one may choose to avoid collecting and sorting food wastes during the hottest summer days to avoid encountering bugs and pungent odours.

7.2 Special Documentation

A letter must be obtained from the Ministry of the Environment authorizing the collection of the waste from commercial businesses for purposes of the composition study. The private waste hauler participating in the Waterloo Study requested and received a letter from the Region confirming the confidentiality of the waste information obtained in the study.

The procedure to obtain Ministry approval for solid waste sample collection by municipalities undertaking waste composition studies is as follows:

A letter requesting Ministry approval for temporary collection of solid waste samples shall be mailed by the interested municipality to:

Mr. Dave Crump
Operations Coordinator
Operations Division
Ministry of the Environment
14th Floor, 135 St. Clair Ave., West
Toronto, Ontario
M4V 1P5

The letter shall include, but not be limited to the following type of information:

- Background and reasons for undertaking the study.
- Study objectives.
- Study approach.
- Contractor's name.
- Collection area.
- Approximative number of samples to be collected.
- Approximative weight of each sample.
- Estimated duration of the project.

7.3 Waste Collection Methods for Waste Quantities and Composition

In the Regional Municipality of Waterloo as with most municipalities, private waste haulers are usually contracted to remove the waste from commercial businesses, except in the downtown core of Kitchener and Waterloo where waste collection was three times per week or daily, respectively. In the Waterloo Study, commercial haulers provided bulk-lift refuse containers of various sizes (2 to 8 cubic yards) in which a firm's waste was accumulated and picked up as required. In most cases, wastes are placed, loose, into the bulk bins; however, some businesses might be using compactor type bulk refuse containers.

Waste sampling procedures will vary depending on whether the waste is loose or compacted. In the former case, for the Waterloo Study the entire contents of the container were unloaded, weighed in a chicken wire/wood "crib" mounted on a scale (see Figures 2 and 3) and placed in 4′ x 4′ x 4′ heavy duty corrugated containers ("gaylords") in the back of a cube van and taken to the Waterloo landfill site (parking lot of the Recycling Office) for sorting (see Figure 4).

Unloading waste from a compacted entanglement of loose and bagged refuse in a 6 or 8 cubic yard bin during the Waterloo Study was found to be very difficult. It was decided that only half of the contents of the bin could be conveniently and efficiently unloaded and weighed, given the arduous task and the time requirement. The weight of the entire bin was estimated on a volume basis from the weight of the sample that was removed, i.e., usually several hundred kilograms. All loose waste was set aside for sorting; bags of refuse were randomly placed into two piles, with an equal number of bags in each pile. One pile was randomly selected for sorting, the other pile was returned to the bin.

7.4 Waste Collection Methods for Waste Quantities Only

Two sampling methods can be used to determine the quantity of waste generated at each firm. In the first method, the field crew must weigh the waste in the refuse containers before putting the waste in the cube van for transportation to their base for sorting. As noted above, the frequency of waste collection at each firm should be obtained from the owner or manager. The field crew can obtain the employment figure for each business at the time of the interview or by telephone.

When it is not possible to obtain the number of full- and part-time personnel from each firm, the figures for total employment can be used in the regressions of employment versus waste quantity. This is compatible with the data gathered by Statistics Canada.

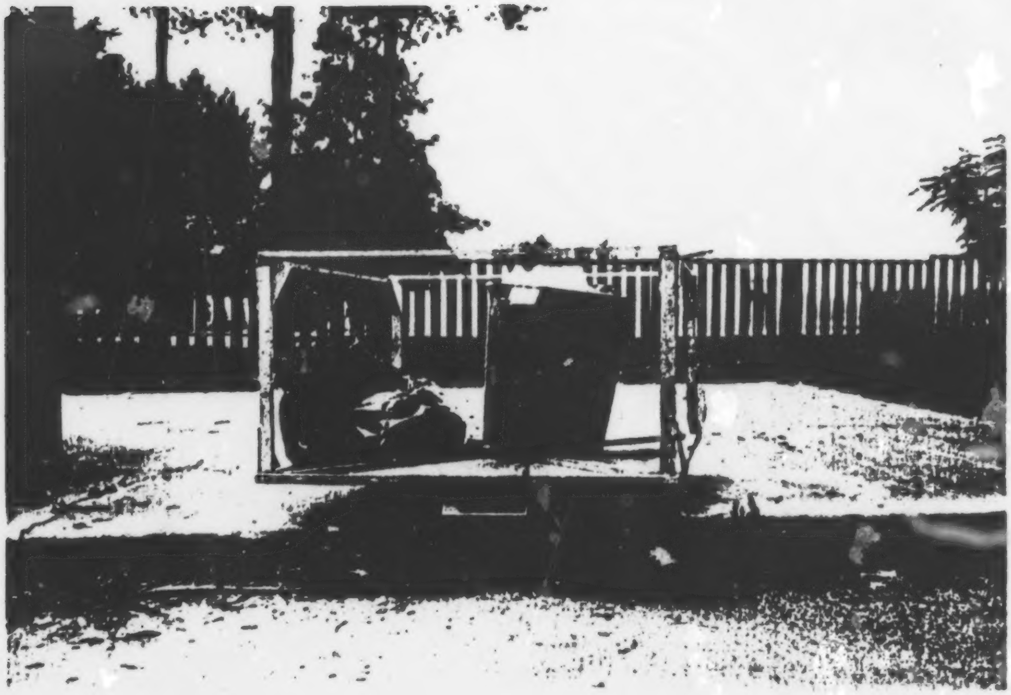

FIGURE 2: WEIGHTING COMMERCIAL WASTE IN A CRIB MOUNTED ON AN ELECTRONIC DIGITAL SCALE

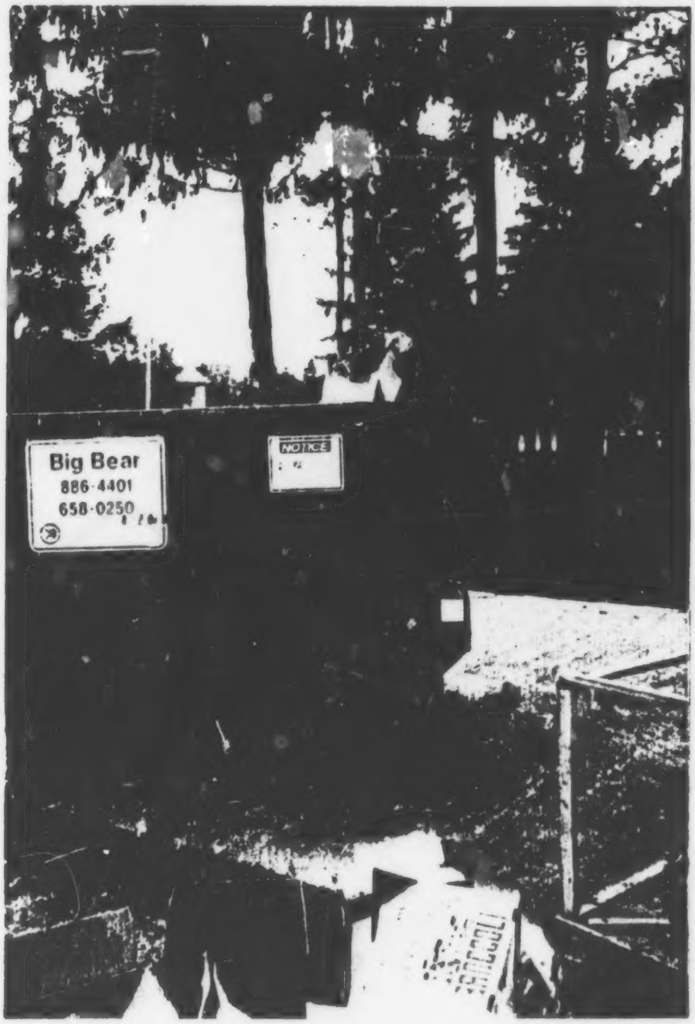
Big Bear
886-4401
658-0250
NOTICE

FIGURE 3: REMOVING WASTE FROM A COMMERCIAL WASTE BIN

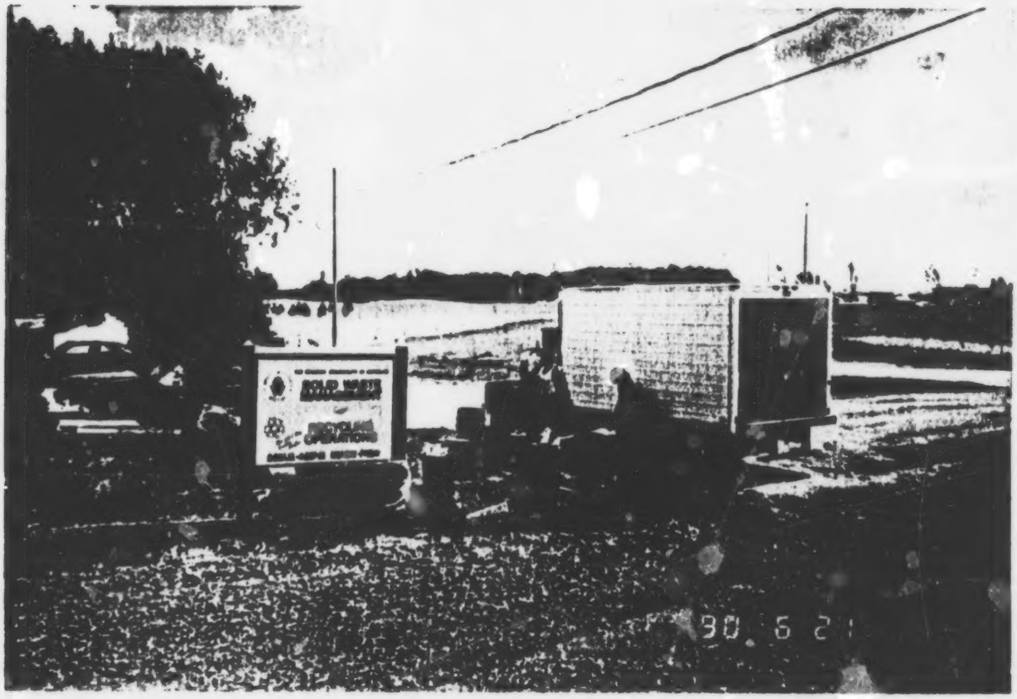
SOLID WASTE
OPERATIONS
30 6 21

FIGURE 4: SORTING A WASTE SAMPLE AT THE LANDFILL SITE

The first method enables one to get waste quantity information from small and medium size businesses. The method is very labour intensive and time consuming but works well for small loads of loose waste. The method is not satisfactory for refuse compacted in 6 to 8 cubic yards containers. The latter containers may be frequently encountered at some of the larger locations.

The second procedure is applicable to all bulk containers irrespective of bin size or degree of waste compaction. In the Waterloo Study, a scale initially developed to weigh loads of sand and gravel carried in the scoop of a front end loader had been adapted for use on overhead (front-end) loading garbage trucks. The scale worked off of the hydraulic lift system that raises and lowers the arms of the bin hoist. A Wray-Tech Model WT4000/6000 (obtained from Woolsey Equipment Sales Ltd., Ottawa) was installed on an overhead packer truck and calibrated with the assistance of the Toledo Scale Company, Hamilton, Ontario.

The bulk waste weighing procedure is a two-step process. First, the bin and waste contents are weighed. Then the contents of the bin are dumped into the truck and the empty bin is weighed. The weight of the bin contents is determined by subtracting the weight of the empty bin from the weight of the bin plus contents. Again, employment data is obtained for these firms, either by telephone or directly visiting these firms after the waste has been collected.

Participants in the waste composition study should be assured of confidentiality of the waste generation and composition information.

7.5 Information to be Obtained at the Time of Sample Collection

A field note book should be carried during the sample collection to note general information and any odd occurrences that may be encountered. General data which should be obtained from every establishment should include:

- company name,
- company address,
- number of employees,
- total weight of refuse,

- number of days refuse generated,
- frequency of refuse collections per week,
- refuse pick-up days,
- size of refuse bins, and
- percentage of bagged waste sampled (for composition).

7.6 Data Obtained for Per Employee Waste Generation Rates

As noted above, the frequency of waste collection at each firm should be obtained. The field crew must also obtain the employment figure for each business at the time of the interview or by telephone.

Bin collection frequency can be determined from the hauler's records and a daily generation rate (kg/day) of waste was determined for each firm. At the conclusion of the field work, the employment and waste generation data can be plotted on separate graphs for each of the commercial groupings. The length of the "work week" is different for different SIC groupings. Some businesses are open 7 days a week (e.g., restaurants, and hotels) and some are open for 6 days (e.g., supermarkets, banks, and automobile dealerships), while some are open for 5 days (e.g., printing shops).

When it was not possible to obtain the number of full- and part-time personnel from each firm, the figures for total employment can be used in the regressions of employment versus waste quantity. This is compatible with the data gathered by Statistics Canada.

SECTION 8

STAGE 4 - WASTE SORTING

8.0 STAGE 4 - WASTE SORTING

8.1 Equipment Set-Up and Sorting Commencement

Before actual sorting, it is necessary to develop a time efficient and accurate sorting strategy. In the Waterloo Study, a large sheet of plywood, 2.4 m by 1.2 m in size, was laid across two clamp-style work-horses to form a table. Four rows of six garbage cans were then aligned behind the table. Each sorter positioned themselves between two rows of cans, with an additional can in front of them (beneath the table), as well two cans are placed on the table. This positioning will optimize the amounts of material types that can be sorted in a timely fashion. This set-up will vary according to convenience depending upon the quantity of certain wastes and diversity of materials sampled. Each member of the field crew should sort one garbage bag/can at a time, tossing material to the defined waste composition cans. Such a system prevents confusion and time wasted in walking to various scattered cans.

8:2 Sample Sorting and Data Management

In the Waterloo Study, sorting occurred at the regional landfill site in order to avoid unnecessary interference and possible spillage of garbage on the commercial establishment's property. It may be possible to arrange for sorting to take place at similar site.

The commercial waste composition data sheets (Table 5) which were used for logging the weights of the various waste materials encountered in the samples in the Waterloo Study can be adapted to suit other waste composition studies. After sorting the waste into categories, each category should be weighed and its relative contribution to the total sample weight determined, i.e., percent of the waste composition. Waste materials that can not be easily categorized, should be separately identified (described and weighed) on a "miscellaneous" table, accompanying the main waste composition table for each sample. The total weight of materials in the "main" and "miscellaneous" lists should equal 100% of the sample weight.

TABLE 5: WASTE COMPOSITION DATA FIELD SHEET

Town:
SIC:
Sample # :
Collection Dates:

Ministry of the Environment
Waste Composition Study

GORE & STORRIE LIMITED

(1) Paper	(a) Newsprint					
	(b) Fine Paper / CPO / Ledger					
	(c) Magazines / Flyers					
	(d) Waxed / Plastic / Mixed					
	(e) Boxboard					
	(f) Kraft					
	(g) Wallpaper					
	(h) OCC					
	(i) Tissues					
(2) Glass	(a) Beer	(i) refillable				
		(ii) non-refillable				
	(b) Liquor & Wine Containers					
	(c) Food Containers					
	(d) Soft Drink	(i) refillable				
		(ii) non-refillable				
	(e) Other Containers					
	(f) Plate					
	(g) Other					
(3) Ferrous	(a) Soft Drink Containers					
	(b) Food Containers					
	(c) Beer Cans	(i) returnable				
		(ii) non-returnable				
	(d) Aerosol Cans					
	(e) Other					
(4) Non-Ferrous	(a) Beer Cans	(i) returnable				
		(ii) non-returnable				
		(iii) American				
	(b) Soft Drink Containers					
	(c) Other Packaging					
	(d) Aluminum					
	(e) Other					
(5) Plastics	(a) Polyolefins					
	(b) PVC					
	(c) Polystyrene					
	(d) ABS					
	(e) PET					
	(f) Mixed Blend Plastic					
	(g) Coated Plastic					
	(i) Nylon					
	(i) Vinyl					
(6) Organic	(a) Food Waste / Rodent Bedding					
	(b) Yard Waste					
(7) Wood						
(8) Ceramics / Rubble / Fiberglass / Gypsum Board / Asbestos						
(9) Diapers						
(10) Textiles/Leather/Rubber						
(11) Hazardous Wastes	(a) Paints / Solvents					
	(b) Waste Oils					
	(c) Pesticides/Herbicides					
(12) Dry Cell Batteries						
(13) Kitty Litter						
(14) Miscellaneous						
			TOTAL kg		TOTAL kg	

SECTION 9

STAGE 5 - DATA ANALYSIS AND REPORT WRITING

9.0 STAGE 5 - DATA ANALYSIS AND REPORT WRITING

9.1 Estimates of Average Per Employee Waste Generation Rates

Each sample observation may provide information on the number of employees and the total weekly waste generation for the establishment. This permits two different kinds of statistical generalization. First, it is possible simply to divide the total waste by the number of employees to obtain an estimate of waste generation per employee. Several of these estimates can then be used to determine average values and standard deviations.

Second, more information can be extracted by plotting total waste against employment for each observation. This provides:

(1) a visual pattern of the overall variability in the results, an evaluation of the relation between waste generation per employee and size of store (e.g., are big stores more or less efficient with respect to waste generation?);

(2) a measure of the waste reduction efficiency of individual stores relative to the group; and

(3) an evaluation of the effectiveness of the sample selection in relation to store size.

By fitting a regression line to the graph one can obtain another measure of the regularity of waste generation, i.e., the regression coefficient r^2. Another estimate of the relation between waste generation and number of employees is the slope of the regression line (b).

In the next step in the analysis, estimates of waste generation per employee are used to estimate total waste generation within the study area. Either the mean value of waste per employee or the regression slope (b) can be selected. The regression slope should be used as long as it was adjudged reliable; otherwise the mean value should be used. The reliability depends on both the regression coefficient (over 0.5) and the scatter of observations on the graph. A sample with a wide variety of different stores sizes may be deemed acceptable. Those where the observations are clustered together around the same size store should be rejected. In the ideal case, where there is perfect correlation between waste generation and employment, the intercept (a) is expected to be zero and the mean value should equal the regression slope (b). For further discussion of regression analysis the reader may consult Modern Elementary Statistics (ref. 6).

9.1.1 Estimates From Average Waste Weight Per Employee Data

For each SIC group of commercial business, the daily waste weight generated at each firm can be divided by the number of employees to obtain the weight of waste per employee per day. An average estimated waste generation rate (± 1 Standard Error) can be calculated for the SIC sector from the sample data.

9.2 Estimation of Waste Generation by Commercial Sector in the Entire Municipality

The estimation of commercial waste generation for the entire municipality combines two kinds of information. First, various employment data can be used to estimate total commercial employment and employment for various types of commercial activity in the entire municipality. Second, the field work provides estimates of the amount of waste generated per employee by type of commercial activity. By combining these two kinds of information the final estimate of commercial waste generation is obtained for the entire municipality.

It is much more important to make accurate estimates for the larger places than for the smaller ones. (Note: Familiarity with the local economic structure is required to make minor adjustments to Statistic Canada employment information where needed).

For the Region as a whole, the share of commercial jobs was 32.8 percent in the 1986 Census and 38.7 percent in 1989 according to the Region's Planning Department--a difference that reflects variations in definitions in the two data sets. Despite these differences, the regional employment survey permitted an estimation of the share of regional commercial employment to be allocated to each municipality. This should assist in estimating the share of commercial waste generation.

9.3 Sources of Potential Error in Employee Waste Generation Estimates

Table 6 lists the kinds of errors that will affect the accuracy of the employee waste generation estimates presented herein. An estimate of the magnitude and "direction" of the error is also given.

Error in the estimates of waste generation for a municipality can occur in two ways. First, the labelled Waste Survey in Table 6 is derived from the evaluation of ratios of waste generation per employee. When the error occurs in the sampling procedure, due to store-to-store differences in the ratios this error can be reduced by increasing the sample size. Difficulty in identifying and clarifying the correct type of business SIC group can also contribute to that error and is more difficult to evaluate. The error depends on the significance of identifiable differences in subtype s of commercial activities, perhaps segmented by location or brand names or product mix. A store incorrectly identified could lead to a sizeable error in a small number of samples. In the Waterloo Study, local business directories provided the SIC type for the businesses. Measurement errors, e.g. weight of wastes, should be relatively minor.

The second form of error (possibly embodied in the remainder of Table 6) is related to the estimation of total commercial activity in various sectors, based on various data sources. Each data source has its own problems. These errors cannot be reduced by increasing the sample size. Census data are comprehensive, but begin with the undercounting bias that averages this percent across the population as a whole.

There may be other systematic errors in reporting the SIC types, such as, whether the person is actually working or the location of the work place. Most of the error in the Labour Force survey is derived directly from the sample size, since there is not detailed information on location of SIC groups. The regional employment survey provided greater spatial detail but carried a high level or error due to non-response and error in SIC or number of employees. Local governments are not professional data gathering agencies and employers are not required to respond to survey requests.

TABLE 6 ACCURACY IN WASTE ESTIMATION - SOURCES OF POTENTIAL ERROR

Type of Data	Type of Error	Magnitude of potential error (%)[1]	Bias	Level of Observation
Census Employment	Undercounting	2-5	negative	CMA, sector
	Misclassification	5 (?)	neutral	sector
	Employment Definition	5 (?)	positive	CMA, sector
	Location (JTW)[2]	5-10	small places	municipality
Labour Force Survey	Sampling Error (largely eliminated by tracking monthly estimates over time)	2-5	neutral	CMA
Regional Employment Survey	Reporting & Tabulating	up to 10	neutral	municipality, sector
	Misclassification	up to 10	neutral	sector
	Employment Definition	minor		municipality, sector
Waste Survey	Sampling Error	standard deviation up to 15%	neutral	store
	Measurement	5 (?)	?	store
	Classification	10	10 (?)	store

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[1] Best estimate based on professional judgement (J. Simmons)

[2] Journey-to-work

The Waterloo Study was thus an exploratory one, and the sampling errors in the waste survey predominate. As more information is integrated from additional work, and samples become larger and more precisely targeted, these waste survey errors can be reduced and made small relative to the problems of employment estimations and projections.

9.4 Per Employee Waste Generation Rates

As indicated earlier, for each company participating in the study, a daily, per employee waste generation rate can be determined (kg per employee per day). The weight of waste generated by a company during one "work week" is divided by the number of days in their "work week", either 5, 6 or 7. The weight per day is divided by the total number of employees in the firm. An estimate of the employee waste generation rate per day for each SIC group, or sub-grouping, is obtained by averaging the information for all companies in the same SIC group or sub-grouping. The following illustrates the above steps:

1. $\frac{(\text{kg/wk})}{6} = \text{weight per day}$

2. $\frac{\text{weight per day}}{\text{total no. of employees}} = \text{employee generation rate per day}$

3. $\frac{\text{sum: employee generation rates}}{\text{n (no. of employees)}} = \text{average employee generation rate per day}$

For each two-digit SIC group or sub-grouping, the daily waste generation rate for each firm can be plotted against the number of employees. Linear regressions can be calculated for the data and the resulting coefficients representing the employee waste generation rate (the coefficient b in the regression equation: $y = a + bx$) can be compared with the estimates of daily waste generation for the SIC sector, determined by the averaging method.

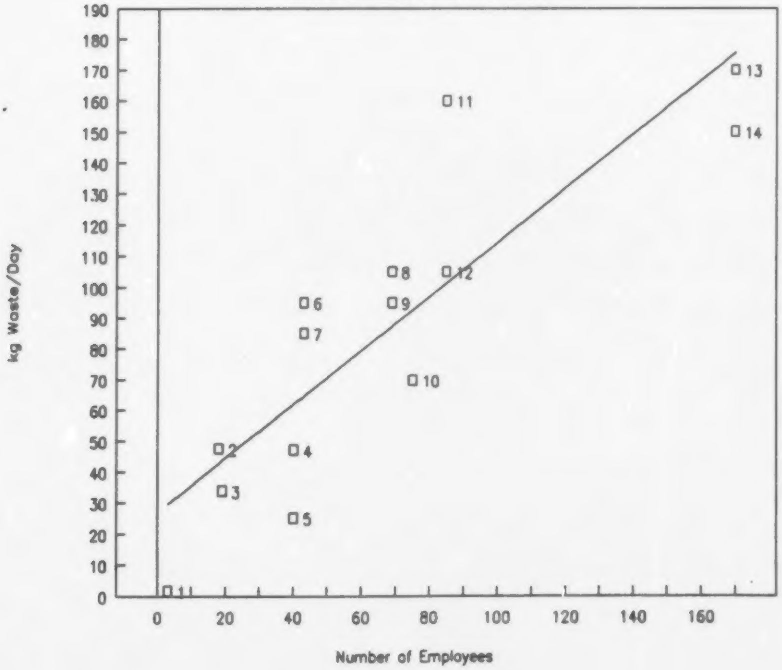
An example of the average per employee waste generation rate and the error standard for SIC group 631 sampled in the Waterloo Study is provided in Table 7. An example of a corresponding scatter graph which shows a strong correlation between waste generation and employment is provided as an example in Figure 5.

TABLE 7 SIC GROUP 631, WASTE GENERATION DATA (KG/EMPLOYEE/DAY) FOR THE AUTOMOBILE DEALERS

Sample #	Total # of Employees	kg Waste/Day	kg Waste/ Employee/Day
1	3	1.71	0.57
2	18	47.52	2.64
3	19	33.86	1.78
4	40	46.93	1.17
5	40	25.06	0.63
6	43	95.00	2.21
7	43	85.00	1.98
8	69	105.00	1.52
9	69	95.00	1.38
10	75	69.70	0.93
11	85	160.00	1.88
12	85	105.00	1.24
13	170	170.00	1.00
14	170	150.00	0.88
		AVERAGE	1.41
		+/- SE	0.165

FIGURE 5: SIC GROUP 631

GRAPH OF WASTE GENERATION DATA



9.5 Estimation of Commercial Waste Generation in the Regional Municipality of Waterloo

Table 8 has been included in this procedure manual for illustration purposes only. Table 8 disaggregates the various SIC categories from Statistics Canada to conform to the groups used in the Waterloo Study. The table also contains estimates of total municipal employment for each of the commercial sectors. To obtain an estimate of the municipality's employment from the Census Metropolitan Area (CMA) data in the Census simply multiply by 1 ± the percent difference in the spatial definition of the study area (i.e., the municipality's boundaries may be slightly larger than those of Statistic Canada for the municipality). To convert the 1986 employment to 1990 employment, multiply by the estimated commercial employment growth. The application of growth rates in this manner does not account for fluctuations occurring as a result of economic fluctuations, such as during a periods of recession. These employment estimates are multiplied by the waste generation per employee to estimate total commercial waste for the SIC group listed.

The data in the right hand column of Table 8 are estimates of weekly waste generation rates (kg/employee/week) for 13 commercial SIC Groups. The weekly per employee waste generation estimate for each SIC group is multiplied by the total municipal employment for the group to obtain the weekly waste contribution (kg/week) from the SIC group. Note that the kg/wk are presented in 1,000s, i.e., the actual values are 1,000 times higher than the number entered in the table, e.g., 342 x 1,000 = 342,000.

The total estimated weight generated by the commercial sector in the Region of Waterloo was also calculated (1,469,400 kg/wk, or approximately 1,469 tonnes/wk or 76,388 tonnes/year).

TABLE 8

AN EXAMPLE OF ESTIMATES OF COMMERCIAL WASTE GENERATION IN A MUNICIPALITY

Activity	Number of Employees[a] (1990)	Waste Generation kg./empl./wk.	Total Waste kg./wk. x 10^3
Retail			
Food (SIC 60)	6195	55.2	342.0
Clothes (61)	2215	3.6	8.0
Furniture (62)	1430	10.1	14.4
Auto (63)	5400	12.6	68.1
General (64)	3825	6.8[b]	26.0
Misc. Retail (65)	3455	29.6	102.3
Bldg. Suppl. (56)	1495	34.2	51.1
Non-store (69)	590	1.0[c]	0.6
Sub-total	24605	-----	612.5
Finance and Services			
Banks (70)	2900	1.0	2.9
Other Fin. (71-77)	18970	3.0[f]	575.8
Services (97-99)	9080	1.0[c]	9.1
Sub-total	30950	-----	587.8
Hotels (91)			
No Restaurant[d]	520	43.5	22.6
With Restaurant	1035	12.0	13.0
Sub-total	1555	-----	35.6
Restaurants (92)			
Licensed[e]	5520	21.1	116.5
Unlicensed	2760	21.1	58.2
Sub-total	8280	-----	174.7
Recreation (96)	1800	2.1	3.8
Total Commercial for SIC Groups Listed Above	**67190**		**1469.4**

[a] Figures derived from Canada Census data and local planning statistics reflecting an adjustment for spatial difference plus growth rate to bring dated information into current years.

[b] The average of categories 61 and 62.

[c] Because of the similarities in activities, the employee waste generation estimates for non-store and service commercial entities were estimated to be the same as banks.

[d] Estimated as one-third of hotel employment.

[e] Estimated as two-thirds of restaurant employment.

[f] Estimate from Ministry of Government Services (personal communications with M. Sidhwa; note that this estimate is tentative and awaiting confirmation).

SECTION 10

EVALUATION OF METHOD

10.0 EVALUATION OF METHOD

10.1 Timing of the Waterloo Study

It must be realized that the management of waste is dynamic and as such future waste composition studies should make use of additional information and circumstances which may develop with time.

The Waterloo Study did not attempt to quantify the amount of materials being diverted from a company's waste stream; the waste composition, therefore, does not include those materials which were being diverted (if any) through any outside agencies.

Because of the scope of the work, it was not possible to design a waste sampling program that would permit the collection of a sufficient number of samples so that statistical analyses could be applied to the waste composition data. It must be pointed out that the Waterloo Study was a prerequisite study; the level of variance between the estimated and actual waste composition is not known. More field work must now be done in other municipalities to augment the data contained in the Waterloo Study.

10.2 Graphical Presentation of Waste Generation Versus Employment--- Potential Method to Evaluate Company Waste Management Performance?

Graphs of the Waterloo Study data for waste generated by businesses, versus employment displayed the variance of "waste management performance" that had been encountered in the sample of businesses. In theory, the waste generated by businesses should be closely correlated with employment and the data should tend to fall about an imaginary linear projection line. If there are data that are greatly removed from the linear tendency of the majority of the sample points, those businesses may be targeted for investigation with respect to their waste management practices. For example, a business with exceptional waste minimization efforts will show up as a data point that is well below the general linear grouping of businesses; a business with poor waste management policies will show up as a data point that lies well above the linear grouping of businesses.

Therefore, municipalities are advised to plot the employment/waste generation ratios in order to "get a feel" for practical problems that they can address in specific companies. A simple average of employee waste generation rates would suffice if rates, alone, were important.

While the per employee waste generation rates are simply taken as the values of 'b' (slope), one may legitimately modify these rates, based on the number of employees in a given firm. In other words, one may divide the value for 'a' (kg/day) by the number of employees in a firm and add this quotient (in units of kg/employee/day) to the value of 'b'. As employment increases, the impact of the 'a' (employment) on the value of 'b' will decrease. No company-specific adjustments were made to waste generation estimates because we were interested only in an average estimate, representative of the SIC group as a whole, i.e., the value of 'b' alone.

10.3 Usefulness of Landfill Data in Estimating Commercial Refuse Quantity

Generally, there are three systems for the collection of waste from commercial sources and delivery to landfill sites: (1) residential garbage trucks (2) front end (or over-head) packer trucks and (3) "dedicated loads" from large supermarkets and large malls. Residential garbage trucks frequently make collections from commercial businesses as part of their daily routing through a municipality. The load is weighed at the scalehouse and the weight is normally recorded as "residential". The fraction of the waste collected from commercial businesses cannot be accurately determined under these circumstances.

Haulers using front end packer trucks frequently make between 25 and 50 refuse collections from customers before proceeding to a waste facility. A typical collection route for one of these trucks may include stops at: schools, senior citizen's homes, commercial businesses, industries, hospitals, condominiums, apartment houses, malls, etc. It is apparent that no matter what category is chosen to designate the "source" of the waste, when the load is weighed at a disposal facility, the choice will not reflect the heterogeneity of the waste in the truck. It is normal for these loads to be recorded as either "commercial" or "industrial".

Given the nature of the waste delivery systems from generator to transfer station or landfill site, most of the scalehouse data do not give a reliable picture of commercial and industrial waste generation, and to use that data in estimating waste composition would be misleading. Yet, scalehouse "records" are the basis for the widely held generalization that residential waste is "40%" of the total waste stream and commercial and industrial waste accounts for "60%". There is good reason to doubt the accuracy of this or any other percentages that rely on scalehouse weight data. The method that we have developed in the present study will enable municipalities to make a reasonable estimate of the waste generated by the commercial business sector. The method described in Volume I of the Waste Composition Study can be used to estimate the residential waste stream.

10.4 Verification of the Employee Waste Generation Estimates

In the absence of an alternative method to directly estimate the employee waste generation rates, one must defer to a comparison of the data with published literature values. Such a comparison is given in Table 9.

The following verification method is suggested in future studies. Using small "strip malls", estimate the total waste generation rate for each business, using the SIC per employee waste generation rate estimates (from this study) and the employment figure for each business. Compare the estimated sum of waste generated for the entire sample mall with the actual weight of waste produced by the mall.

10.5 "Light Industry"

The Standard Industrial Classification system uses the term "industry" throughout (e.g., "Retail Trade Industries"), but no categorical distinction or definition is given to the term "light", with respect to any kind of industry. Commercial businesses are

TABLE 9

COMPARISON OF PER EMPLOYEE WASTE GENERATION RATES: RHYNER & GREEN (REF. 14) AND PRESENT STUDY[1]

SIC[2]	Description	Rhyner & Green (ref. 14) tonnes/emp /yr	kg/emp /day[3]	Present study kg/emp /day
50-51	Wholesale trade	1.70	6.5[4]	
52	Retail building materials	1.44	4.6[5]	5.7
53	Retail general merchandise	0.25	0.8[5]	1.1
54	Retail Food	1.97	6.3[5]	9.2
55	Auto sales, service	0.41	1.3[5]	0.9-4.6
56	Retail apparel	0.41	1.3[5]	0.6
57	Furniture	1.06	3.4[5]	1.7
58	Eating & drinking place	2.07	5.7[6]	3.0
59	Miscellaneous retail trade	0.89	2.0[5]	4.9
60-67	Financial operation	1.18	4.5[4]	0.2-0.6
70	Hotels	1.95	5.4[6]	1.7-6.2
72	Personal services	0.38	1.5[4]	
73	Business services	0.68	2.6[4]	
76	Miscellaneous repair	1.51	4.8[5]	
79	Amusement recreation	0.66	1.8[6]	2.1
89	Miscellaneous services	0.68	2.2[5]	
90	Government[7]	0.68	2.6[4]	

---

[1] data from Table 7 of Volume II of the Ontario Waste Composition Study.

[2] numbering for the U.S. SIC code differs from the Canadian code.

[3] calculated from Rhyner & Green data for tonnes/emp/yr.

[4] five day work week (260 days/yr): tonnes/emp/yr ÷ 260 work days/yr x 1000 kg/tonne = kg/emp/day.

[5] six day work week (312 days/yr): tonnes/emp/yr ÷ 312 work days/yr x 1000 kg/tonne = kg/emp/day.

[6] seven day work week (365 days/yr): tonnes/emp/yr ÷ 365 work days/yr x 1000 kg/tonne = kg/emp/day.

[7] value not reported; Miscellaneous Services value used.

also called industries, so one cannot look to the SIC code to assist in distinguishing "light" industry from "heavy" industry.

Semantic arguments and clear problems of nomenclature aside, an arbitrary decision was made to call the shoe manufacturing industry (SIC 17) and the printing industry (SIC 28) "light industry". No special methods were applied to the data gathering procedures for these businesses and therefore the data are considered tentative. This study describes sampling procedures for commercial activities that closely serve the residential sector. Longer term sampling procedures are needed to assess industrial waste stream characteristics.

SECTION 11

RECOMMENDATIONS FOR FURTHER REFINEMENT

11.0 RECOMMENDATIONS FOR FURTHER REFINEMENT

The methods employed in the commercial portion of the Ontario Waste Composition Study have been demonstrated on a selection of commercial businesses in the Regional Municipality of Waterloo. Within the commercial sectors in the Region there is a relatively high awareness of waste diversion options that will reduce waste disposal costs and encourage recycling. Therefore, we cautiously regard the qualitative and quantitative data presented in the Waterloo Study as a best estimate under constantly changing circumstances.

The Waterloo Study has developed a procedure for estimating the amount of waste generated by commercial activities within Ontario urban areas and began with the process of integrating the complex data inputs required. What are the next steps?

The Waterloo Study has employed a two-stage estimation process: (1) the development of ratios of waste generation per employee; and (2) the estimation of commercial employment composition for the municipality as a whole. Each step poses different problems. The following recommendations are submitted for further refinement of the methodology:

1. The waste generation and composition data base will require many more samples than what were taken in the Waterloo Study in order to cover the full range of commercial activities. No one study will have the resources to undertake a complete evaluation; the research results must be accumulated over many studies and evaluated over time. Fortunately, there is no inherent reason that a business in any part of the province cannot be used to estimate waste generated elsewhere--unless local waste management policies differ significantly.

   This means that each study should use the same SIC identification to code commercial activity and the same methodology for measuring waste output and composition. A central agency (e.g., the Ministry of Environment) may have to take the responsibility for organizing and evaluating the data.

2. It will also be necessary to monitor any changes over time in waste generation that may reflect innovations in policy, technology or corporate behaviour. The date of each sample must be retained and/or it may be necessary to identify sample locations that can be restudied over time in order to minimize sampling error.

3. To better understand the effect of recycling behaviour on the data gathered, it is recommended that employees/management of participating firms be asked to describe the nature and extent of any source separation recycling activities.

4. The immediate priorities for sampling can be identified from the results of this study. Those commercial activities that employ large numbers of people must be further investigated in order to improve sample size and reveal any significant variation within the SIC groups; this includes the diverse set of office and financial activities. Conversely, those activities with a high rate of waste generation per employee, such as food stores and restaurants, must be sampled repeatedly because of their importance to the overall waste generation. Those sectors where the observed sample variance (standard deviation) is high require larger samples to improve overall accuracy, possibly by isolating subgroups within the SIC. Activities that generate policy-relevant waste materials should be given special attention.

5. The future development of employment estimates requires two divergent approaches. First, substantial savings may result from a centralized standardized analysis of employment that applies the same set of data, techniques and projections to all urban areas--much as the Ontario Statistical Centre has developed a common set of population forecasts.

   At the same time, municipalities have better information about local peculiarities and exceptions to the employment structure. These special cases, e.g., community colleges, tourist attractions, shopping concentrations, as well as manufacturing activities, may require special attention by a local agency.

6. During the course of the Waterloo Study, insights were noted regarding the effectiveness of waste management practices of some firms. For example, for automotive repair businesses, it appears that employee's tend to use the general refuse bin for discarding metal waste materials, despite the fact that a scrap metal bin has been made available.

Such insights, when communicated to the management of the firm provide an immediate opportunity to help that firm improve the efficiency of their recycling efforts.

There was also an indication in the Waterloo Study that differences exist in per employee waste generation rates in small grocery stores and in larger supermarkets.

The demonstrated method for estimating the rate of employee waste generation has the potential to be used as a waste management tool by municipalities. The distribution of the daily waste generation rates versus employment data, exhibited in the graphs for each SIC sector, could enable municipal waste management personnel to prioritize their "remedial" waste reduction efforts by planning to visit those companies whose waste generation rates seem out of line with the general waste-to-employee relationship.

ACKNOWLEDGEMENTS

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Gore & Storrie Limited wish to acknowledge the assistance provided by the Regional Municipality of Waterloo for the commercial portion of the Ontario Waste Composition Study. Mr. Dick Buggeln of the Region co-ordinated the field work and wrote significant portions of the text.

The concept for the field study was developed following the advice of Dr. Virginia Maclaren that led to extensive discussions with Dr. Jim Simmons (both faculty members in the Geography Department, University of Toronto). Dr. Simmons worked with the Canada Census employment information and accessed other employment data bases in order to develop a picture of employment in the retail commercial businesses in the Regional Municipality of Waterloo. Dr. Simmons also assisted in evaluating the field data and writing portions of the text. The project clearly benefitted from Dr. Simmons' many crucial contributions.

The field crew: David Fox (Gore & Storrie Limited), Richard Stevenson and Lisa Morgan (both from the Region of Waterloo) were responsible for contacting the companies, organizing an often complicated waste collection schedule and sorting the waste. They were a dedicated crew and their efforts are gratefully acknowledged.

A considerable portion of the field work was conducted with the participation of Big Bear Services, Waterloo, Ontario, and the cooperation of Messrs. Bob Knarr, Gary Bell and Bruce Storrer.

Report preparation assistance was provided by David Fox, Brock Harrington, Rob Flindall, Debra Hayes and Chris Taylor of Gore & Storrie Limited, with additional support from Adam Buggeln and Barbara St. Hill.

The Project Managers for Gore & Storrie Limited were Les MacMillan and Jeff Flewelling.

We gratefully acknowledge the strong ongoing support and assistance of Messrs. Neal Ahlberg, Brendan Killackey and Dan Ionescu, Waste Management Branch, Ministry of the Environment.

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APPENDIX A

APPENDIX A

Results of an Empirical Analysis of Commercial Solid Waste Generation Undertaken by T.V. DeGeare and J. E. Ongerth (1971) (ref. 3)

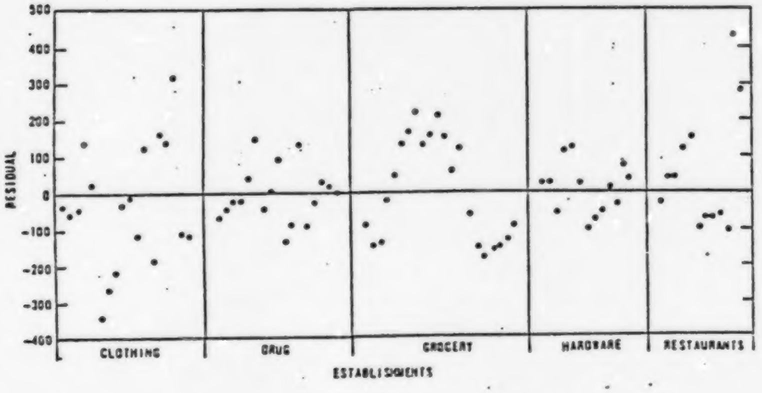

FIG. 1.—REGRESSION EQUATION RESIDUALS (See Table 1 for Data Information)

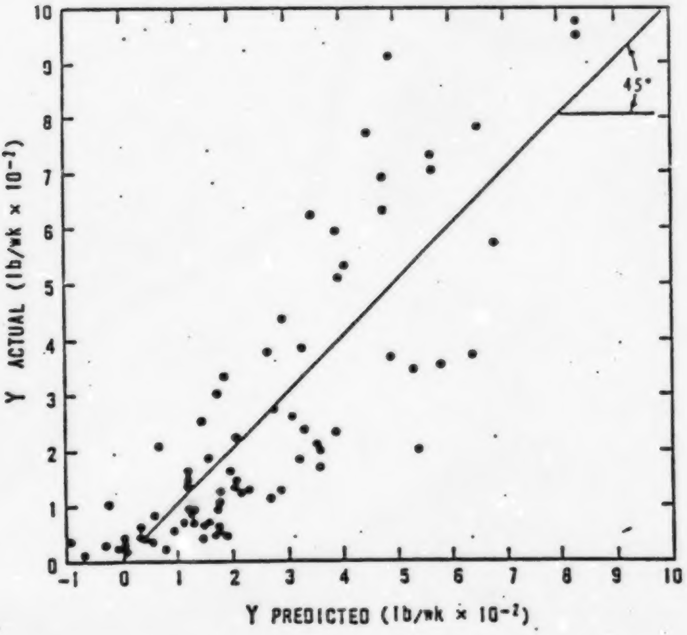

FIG. 2.—ACTUAL VERSUS PREDICTED SOLID WASTE QUANTITIES (All Stores)

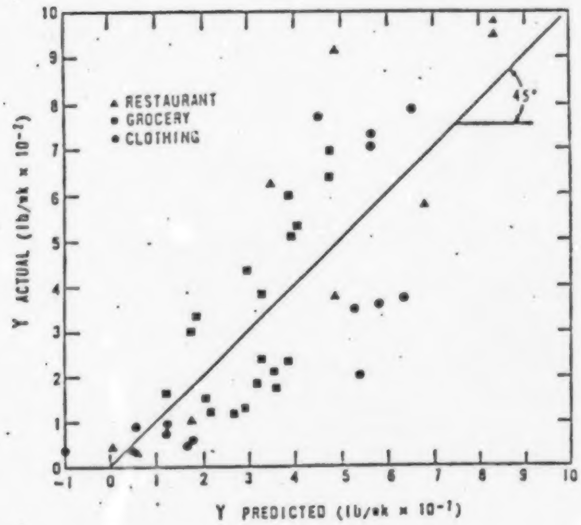

FIG. 3.—ACTUAL VERSUS PREDICTED SOLID WASTE QUANTITIES (Restaurant, Grocery, and Clothing Stores)

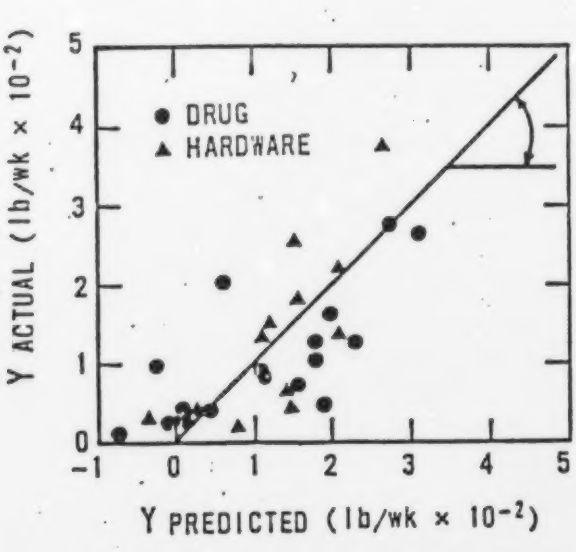

FIG. 4.—ACTUAL VERSUS PREDICTED SOLID WASTE QUANTITIES (Drug and Hardware Stores)

GLOSSARY OF TERMS

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ABS	Acrylonitrile butadiene styrene; a dense plastic found in computer housings, telephone casings, pipe.
accuracy	In a statistical sense, the term gives an indication of the closeness of the results, estimates, etc. to the "true" value.
commercial wastes	Discarded materials generated by commercial businesses as a result of normal activities in the workplace.
correlation of determination	A numerical measure specifying the proportion of variation in Y, the dependent variable, that is explained by the regression line; i.e., by Y's relationship with the independent variable.
dependent variable	The variable we are trying to predict in regression analysis.
ferrous	A metal object containing elemental iron, giving a 'positive' or attractive response to a magnet (Note: other ferromagnetic materials such as nickel would also give a positive response).
mean	The mean or arithmetic mean of a set of values is the sum of the values divided by their number; average.
MSW	Municipal solid waste, usually defined as the sum of residential and commercial solid wastes, and excluding industrial wastes.
non-ferrous	A metal object which does not give a 'positive' or attractive response to a magnet, e.g., brass, lead, aluminum, etc. (Note: other ferromagnetic materials such as nickel are non-ferrous but would give positive response to a magnet).
OCC	Old corrugated containers; variously called, old corrugated cardboard.
PET	Polyethylene terephthalate; the plastic used to manufacture the common 2 litre pop bottles.
polyolefin	In the sense used here, a grouping of chemically related plastics whose chemical building blocks are either ethylene or propylene.
precision	In a statistical sense, the term gives an indication of the repeatability of a series of observations, estimates, etc. The Standard Error is one kind of estimate of the precision or repeatability or "tightness" of the grouping of the observations (=data).

putrescible	A material which is biodegradable; usually a term reserved for animal or vegetable matter.
PVC	Polyvinyl chloride; a plastic containing chlorine; well known as siding, plastic window sashes and frames, pipe and a few rigid containers.
random number table	These tables (which are found in many statistical textbooks) consist of blocks of numbers that meet certain properties of "randomness", including that numbers in the range 0 to 9 are equally likely to occur; and that the numbers are not serially ordered in any way. Starting at any point on the Table, the user moves systematically through the Table taking the required number of digits.
regression	The general process of predicting one variable from another by statistical means.
regression line	A line fitted to a set of data points to estimate the relationship between two variables, ie. line of best fit.
residential waste	Discarded materials generated by individuals in the course of their daily activities at their place of residence; in this case, exclusive of yard wastes and leaves.
scatter diagram	A graph of points on a grid; the X- and Y-coordinates of each point correspond to the two measurements made on some particular sample element, and the pattern of points illustrates the relationship between the two variables.
slope	A constant for any given straight line, the value of which represents how much each unit change of the independent variable changes the dependent variable.
standard deviation	A measure of the variation or difference of sample measurements from the mean of all measurements taken.
standard error	A measure of how much sample means can be expected to fluctuate (±) from the true mean due to chance.
tare weight	The weight of an empty container.
Y-intercept	A constant for any given straight line, whose value represents the predicted value of the Y-variable when the X-variable has a value of 0.